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EDUCATION AND TRAINING OF METALLURGISTS

A JOINT Committee on Metallurgical Education was formed in 1945 by the councils of the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of British Foundrymen, the Institute of Metals and the Institution of Metallurgists to advise them on all matters concerning metallurgical education in the United Kingdom. This Committee has previously issued two reports ("Qualifications for Entrance to University Schools of Metallurgy" (February 1948) and "Recommendations on University Full-time Degree Courses in Metallurgy" (1950)) dealing with the university education of metallurgists, and has now issued a third* which covers the whole field of metallurgical education and training, ranging from the training of operatives in the techniques they practise, to the university education and subsequent training in industry of the highest grade of professional metallurgists. The view expressed in an earlier report that "The Universities are at present, are likely to be and should continue to be the chief source of high-grade technologists" is reaffirmed, and the university schools are urged to expand their output to the utmost of their ability. In line with a growing feeling in industry, it is recommended that university courses in metallurgy should provide education in management and administration, and that undergraduates reading metallurgy should have more opportunity for contact with cultural and humanistic subjects. These are important and significant recommendations which may well point the way which university courses in metallurgy will follow during the next few years.

So far as industry is concerned, the Committee makes two recommendations with regard to graduates. The first is that employers should make the fullest possible use of postgraduate studies available in Britain by financing attendance of suitable employees at one of the recently established Postgraduate Schools of Metallurgy at Birmingham or Sheffield. The second is that formal methods for training graduates immediately they enter industry should be adopted more widely.

Undoubtedly the most important part of the report, and one which is likely to influence future developments most profoundly, is that which is concerned with technologists who obtain their education by part-time study. It is probably not going too far to say that such men are the backbone of the metallurgical industry in those regions of Great Britain where, for many years, there have been part-time courses leading ultimately to a local 'associateship' of a very high standard. Unfortunately, not all regions have provided equal educational facilities; unfortunately, too, not all students have been able to complete the course, and the unsuccessful ones have received no formal qualification when they have

* The Education and Training of Metallurgists. A Report of the Joint Committee on Metallurgical Education of the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of Foundrymen, the Institute of Metals and the Institution of Metallurgists. Pp. 56. (Joint Committee on Metallurgical Education, 4 Grosvenor Gardens, London, 1952.)

reached the limit of their capabilities. The Joint Committee now recommends the rationalization of such part-time education on a national scale, with corporate membership of one of the professional metallurgical institutions (generally the Institution of Metallurgists) as the ultimate goal of all technological pupils in metallurgy. Thus, the Ordinary and Higher National Certificates in Metallurgy and the licentiateship and associateship of the Institution of Metallurgists could be successive rungs on the ladder for those aiming at becoming professional metallurgists by part-time study. The education of such men would be the responsibility of the colleges of technology and the technical colleges, and the report suggests a number of steps that should be taken to enable these institutions to play their part more effectively.

The Committee takes the view that at present the technical colleges of Britain as a whole are not making an adequate contribution to the stock of high-grade technologists and quotes figures in support. It considers that these colleges must be made into better teaching institutions by raising the present standard of staffing. ". . . The provision of good teaching-staff is the first essential in improving the output of high-grade technologists. Compared with this, such matters as technological universities, institutions of technology and degrees in technology are relatively unimportant. . . ." It is a sad reflexion on the present position that the Committee finds it necessary to say that ". . . all who teach technological metallurgy should have been trained and become qualified in the theory and practice of the subject. . . ."

A number of clear recommendations are made on the measures that should be taken to enable the technical colleges to attract staff of the necessary high quality. The difficulty is not a financial one, for salaries in technical colleges are, on the whole, comparable with those in the universities; it is much more likely that the conditions of work are not sufficiently attractive. At present most technical colleges are responsible for the instruction of both technicians and technologists. It is recommended that these two functions should be separated and that instruction in metallurgy at a high level should be restricted to a few selected colleges in the important centres of metallurgical activity, such as London, Birmingham, Glasgow, Manchester, Sheffield, either Cardiff or Swansea and either Newcastle upon Tyne or Middlesbrough. Such colleges would be concerned purely with technology and would be fed with students by the remaining technical schools and colleges, which would be responsible for less advanced teaching.

Much has been said in recent years about the desirability of research being done in the technical colleges, but little progress can be made in this direction if the teaching staffs are overburdened with teaching; the Joint Committee urges that the staffs of technical colleges should be given real opportunities both for research and for spending periods in industry from time to time to keep up to date with developments in industrial technology.

Where the training and education of technicians and operatives are concerned, the report is less definite. The work of the British Iron and Steel Federation in this field is highly praised, and the non-ferrous industry is urged to adopt properly planned training courses on similar lines. Employers are advised to give a real incentive to study by making it known that in filling leading technical positions in the productive departments they would take into account any awards which a candidate had acquired from a recognized educational authority.

The report as a whole is readable and can be recommended to all who are interested in technological education. Those who read it will realize that, as might be expected, the Committee is familiar with conditions in industry and with the educational facilities in Great Britain. The majority of the recommendations are likely to receive widespread acceptance; and they must be given careful consideration by all those who are concerned with the education or training of metallurgists. The views expressed on the technical colleges are realistic, and of particular interest in the light of recent discussions on the need in Britain for a university of technology.

BOTANICAL ASPECTS OF THE FORM PROBLEM

Morphogenesis in Plants

By Prof. C. W. Wardlaw. (Methuen's Monographs on Biological Subjects.) Pp. xi+176+4 plates. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1952.) 10*s.* 6*d.* net.

THIS is a small book about a very large subject. Morphogenesis is a much more familiar word than it was not many years ago, and the discipline it denotes is coming to be recognized as one that involves in its pursuit all the major fields of biological science, culminating in an attempt to explain the integrated 'wholeness' of the organism. The present volume is an examination of some of its problems that are exemplified in the development of the higher plants.

A distinctive feature of these plants is that much of their growth takes place through the activity of meristems. These regions, and particularly the apical meristem of the shoot, provide experimental material for a study of plant morphogenesis somewhat analogous to the young embryo in corresponding studies of animal development. It is this apical meristem with which Prof. C. W. Wardlaw's own work has been particularly concerned, and it naturally occupies a conspicuous position in his book. The author describes with clarity the structure of these growing points and the development of lateral organs from them, together with some of the delicate and beautiful experiments that he and others have performed there.

Emphasis on this aspect of morphogenesis has necessitated the omission, or a much abbreviated treatment, of some others that are also important. The present reviewer would like to see in such a book as this a somewhat fuller presentation of the basic facts of differentiation, polarity, symmetry, regeneration and teratology, for example, together

with the morphogenetic problems raised by these phenomena. The discussion of the various factors involved in the control of plant development is also somewhat unbalanced. The author devotes a good deal of space to growth substances and to the action of genes; but very much less to such important factors as light, temperature, water relations, inorganic chemical substances and mechanical influences. Even to state all the many and varied problems of plant morphogenesis within the limits of a book as small as this one is obviously impossible; but there is danger that an inexperienced reader will get from it a rather one-sided picture of the subject as a whole.

At a time when biologists so strongly emphasize the purely chemical factors in development, it is refreshing to read the author's statement that "a knowledge of chemical processes alone, however precise and detailed it may be, does not and cannot tell us how a particular form comes to be assumed", but that "it is to biophysical and other physical forces . . . that we should look for the immediate or proximate cause of the specific form or structure". Most thoughtful students of the subject will agree with these conclusions.

The author does not minimize the profound complexities which still confront morphogenetic research. "It is a chastening thought," he remarks, "that after so many decades of work, our knowledge of the factors which determine the form of these organs (leaves) is still as incomplete as it proves to be." This might well be said of all the structures of the plant. It is a recognition of this wide and essentially unpenetrated frontier, beyond which lie solutions to so many of the basic problems of biology, that gives to the study of development its challenging appeal.

EDMUND W. SINNOTT

THE MATHEMATICS OF EXPERIMENTATION

The Design and Analysis of Experiments

By Prof. Oscar Kempthorne. (Wiley Publications in Statistics.) Pp. xix+631. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 68*s*. net.

FOR all who design and analyse experiments, Cochran and Cox's "Experimental Designs" has rapidly become a standard work of reference. So extensive has the subject grown, however, that even this large volume, a manual of instruction with comparatively little explanation of principles, cannot deal adequately with confounded and incomplete block designs. Prof. O. Kempthorne's book attempts to fill this gap by presenting the general statistical theory on which all uses of experimental designs rest, together with instructions for constructing, analysing and interpreting some of the more complex designs.

The first two chapters contain a survey of the philosophy of scientific experiment that must surely be too brief for a newcomer to the subject, yet scarcely necessary for the more experienced. A short chapter outlining standard statistical procedures is followed by two important chapters on the theory of least squares, with particular reference to linear hypotheses; the emphasis throughout is on the Markoff approach. From this point onwards, the book is more directly concerned with the structure of different types of design and with the calculation and interpretation of the corresponding analyses of variance. Randomized blocks, Latin squares, and other fully orthogonal systems of classifications are discussed, as are the modifications in analysis required when 'plots' are missing. Full presentation of factorial design, including confounding and fractional replication, occupies several chapters; these relate primarily to 2^n and 3^n arrangements, but the general p^n is included, as also are those with factors at different numbers of levels. Another series of chapters is concerned with lattices; the structure and general method of analysis is explained and related to factorial design, and formulæ appropriate to each type are displayed. This leads naturally to similar discussion of the non-lattice incomplete block designs, balanced and partially balanced. Finally, two short chapters are concerned with problems that arise in the analysis of groups of experiments and of experiments with several treatments applied in succession to the same 'plot'; the accounts given are less complete, but provide an interesting introduction to difficult matters.

The argument is set out mainly with reference to agricultural field trials; but its applicability is in no way restricted to these. The author shows how the mathematical model underlying observational data determines the form of the analysis of variance, and how knowledge of the expectations of mean squares is essential to the interpretation of the analysis; he presents several illustrations of the way in which naïve comparisons of mean squares can mislead. In early chapters, he appears to insist that only randomization tests of significance are legitimate, though he never explains why the assumption of a normal distribution for the error in an additive model should be so objectionable; in much of the later part of the book this principle seems to be conveniently forgotten. "It is, perhaps, unnecessary to state that, if a transformation is used, the best estimates of the treatment means on the untransformed scale are obtained by transforming back the means of the transformed variate"—'untrue' would be preferable to 'unnecessary'. Such errors are happily rare; but the writing is not always clear, and the index is unworthy of so ambitious a book.

This book will unquestionably be valuable to statisticians, yet perhaps its value lies in the details of methods that it contains rather than in the whole view of experimental design that it presents. For routine computation, special formulæ for each design are a convenience; provided that the principles governing their derivation are understood, they are of little interest to the reader of a book which seeks to explain the theory of design and may obscure the unity of the subject. Possibly Prof. Kempthorne has attempted too much, even for a large volume. The great need to-day is for a book that displays the fundamental ideas of experimental design and analysis fully and systematically for the serious student while retaining the comprehensive outlook of Fisher's "The Design of Experiments"; "The Design and Analysis of Experiments" tries to combine with this a manual of detailed instructions for analysis and, in so doing, fails to attain the highest level for either. Prof. Kempthorne is to be congratulated on so nearly succeeding in a difficult task; the ideal book has yet to be written, and ought to make experimental design appear an easier subject than does this one.

D. J. FINNEY

PHILOSOPHICAL AND BIOGRAPHICAL ESSAYS

Ethics and the History of Philosophy

Selected Essays. By Prof. C. D. Broad. (International Library of Psychology, Philosophy and Scientific Method.) Pp. xiii+274. (London: Routledge and Kegan Paul, Ltd., 1952.) 21*s.* net.

PROF. C. D. BROAD here reprints selections from articles and public lectures produced between 1925 and 1949. They are very welcome. The first, biographical, section of the book contains essays on Isaac Newton, John Locke, Henry Sidgwick, J. M. E. McTaggart and W. E. Johnson. The first two celebrate centenaries of famous men, and fulfil their function gracefully. The last two are useful reminders of thinkers recently dead, who were never fashionable and are never likely to be. Yet, when all the more fashionable philosophers are forgotten, they may be remembered—McTaggart for penetrating criticism and daring attempts in philosophical method, and Johnson for fertile conceptions not yet fully developed. Prof. Broad knew them personally and gives a pleasing sketch of their characters as well as a useful brief account of their work. Sidgwick belonged to an earlier generation of Cambridge philosophers, one of the most distinguished, and yet he stands even more in need of commemoration.

The essay on "The Philosophy of Francis Bacon" is the most valuable feature of the section headed "Philosophy of Science". Bacon has been extravagantly praised and extravagantly defamed; very few have stopped to consider carefully what he had to say, and nobody has summed it up better than does Prof. Broad here. The second essay, called "The New Philosophy: Bruno to Descartes", is a clear straightforward account of the main features of Thomist cosmology and of what Descartes proposed to put in its place. Bruno does not come into the story except by being born in 1548, when cracks in the old cosmology were beginning to be visible. In the third essay, "Leibniz's Last Controversy with the Newtonians", Prof. Broad analyses the argument of his correspondence with Samuel Clarke, and gives also some interesting information about Clarke himself. This correspondence makes a difficult and disappointing book. Neither disputant seemed able to see what the other was trying to get at, and both acted in accordance with Disraeli's advice—"Never argue with an opponent; repeat your original statement". This advice is not as useful in philosophy as in politics. Many who have been baffled by the book will welcome Prof. Broad's account, and particularly his analysis of the rival theories of space and time.

The section headed "Ethics" begins with Prof. Broad's inaugural lecture as Knightsbridge professor in Cambridge. This must have made it clear to hesitant undergraduates that during his tenure of the chair the subject of moral philosophy would not be a soft option, but a strenuous intellectual exercise in the analysis of ethical concepts. All four constituents of this section are examples of this. The second one, on "Egoism as a Theory of Human Motives", shows that it is a far more difficult theory than simple-minded egoists suppose. The one entitled "Ought We to Fight for our Country in the Next War", besides its intrinsic interest, must have provided an effective douche of cold water for young intellectuals of the 1930's who were too clever and up to date to fight for anything but ideologies. The last essay, on "Conscience and Conscientious Action", is an admirable example of clarity and good sense on a theme where confusion and nonsense too often prevail, equally on the side of those who claim conscience as an infallible guide and those who claim that it is an illusion of the bourgeoisie.

A. D. Ritchie

TIME AND EVOLUTION

Time's Arrow and Evolution

By Harold F. Blum. Pp. xi+222+4 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1951.) 25*s.* net.

DURING most of the period in which people have argued about things, the legal, medical and military importance of the distinction between a living and a dead animal or man was recognized; but no advantage was seen in erecting the metaphysical concept of the living or non-living state. During the seventeenth and eighteenth centuries a liking for the distinction developed and hardened into a complete dichotomy at the end of the last century. The hardening is often attributed to Pasteur, but this is unfair to him; he demolished with humour and emphasis all the claims made for "spontaneous generation" but still said he thought it could happen. This attitude of believing in a possibility while disbelieving in alleged examples of it permeated the writings of Huxley and Tyndall and has now become common among biologists.

The older writers realized that they knew too little about the primitive state of the earth to make speculation on the origin of life profitable; but as knowledge increases the temptation to speculate increases too, and we now have a steady stream of books on the subject. Dr. H. F. Blum has written one of the better books in this category. He surveys cosmogony, geochemistry, thermodynamics and biochemistry briefly but in a manner adequate for his purpose. He then sensibly points out that primitive forms of life might well pass unrecognized if present-day standards are used, and that a point of origin could arbitrarily be placed almost anywhere along a thousand million-year stretch in the Pre-Cambrian. Making use of this permitted arbitrariness, he chooses as the origin of life the time when proteins first appeared; but he does not explain how, rigidly, he would define a protein. This is the main weakness of the book, for there is no reason for assuming that proteins are the basis of the only possible mode of existence of organisms on the earth. It is obvious that they play a basic part in the most successful way of living, and it is probable that they have done this throughout the five hundred million years of morphological evolution which is the only period about which we have any evidence. But it is a pure assumption that this was also so during the earlier millennia of biochemical evolution. We have so often been led into error by assuming that biology is simple that we should be wary of all unjustified, and it may be said unnecessary, assumptions.

This book achieves what it sets out to achieve. It is popular, written in a popular manner and embellished with some very popular analogies. The author only claims originality for the idea that in the pre-vital phase of the earth's history the adenosine triphosphate cycle evolved and that it engineered the synthesis of primitive nucleoproteins. This is a dis-

tinction that few will grudge him. Nevertheless, much of the argument is presented as if it were novel, and many readers may not realize that all the significant parts appeared long ago in the writings of Huxley, Tyndall and Schafer, for these are neither quoted nor mentioned in the book.

N. W. PIRIE

AFRICANA UPSALIENSIA

Contribution to the Ethnography of Africa

By Sture Lagercrantz. (Studia Ethnographica Upsaliensia, 1.) Pp. xix+430. £9.

Origin of Death

Studies in African Mythology. By Hans Abrahamsson. (Studia Ethnographica Upsaliensia, 3.) Pp. vii+178. £3.

(Uppsala: Almquist and Wiksell; London: Routledge and Kegan Paul, Ltd., 1950–51.)

WE are indebted to the Humanistic Foundation of Sweden for the publication of a series of six anthropological studies dealing with the comparative ethnology of Africa. The two which are reviewed here, "Contribution to the Ethnography of Africa" and the "Origin of Death", are weighty and erudite studies of the diffusion of culture in Africa. The aim of the two authors, who follow the Continental diffusionist school of Graebner and Schmidt, is to test the theories of this school regarding the successive cultures of Africa by a comprehensive examination of all the literature that has been published on African anthropology since the theories were first propounded. S. Lagercrantz, the general editor of the series, does this, in the first and largest volume, by examining particular culture traits grouped under the general headings of food, ornaments, weapons, commerce, art, medicine, divine kingship and religion. Abrahamsson, in the "Origin of Death", which is actually the third volume in the series, makes a similar examination of particular themes of African folk-lore which seek to explain how death came to the world.

Lagercrantz, in his introduction to the first volume, briefly surveys the successive culture theories held by the leaders of this school, ending with those of Baumann, who in 1940 distinguished seven hypothetical cultures—pygmy, Eurafrican steppe, old African (Ankermann's old Sudanese), west African, east Hamitic, north Hamitic and a young Sudanese—which last is also claimed to have a counterpart in the Zimbabwe culture of Rhodesia. Lagercrantz's conclusion is that Baumann "may probably be said to have resolved some of the most important problems of African research in a way that on the whole is likely to prove of permanent value". It is very doubtful if this opinion would be shared by most British or American Africanists, but their aims and methods are entirely different. British social anthropologists are concerned with the study of contemporary African societies as they exist at present or in the historic past. The Uppsala ethnologists are concerned with the interpretation of contemporary African cultures in terms of their origins, and their endeavour is to deduce these origins from a study of the distribution of isolated culture traits which are regarded as the survivals of these earlier hypothetical cultures.

Readers who are interested in the diffusion of particular culture traits will find in these volumes, particularly the first, a mass of interesting material; those who wish to study contemporary African societies will merely be irritated by them; and the scientifically minded will note the absence of any first-hand archæological or anthropological field-work and will wonder whether this technique of culture analysis, useful as it may be in the case of European ethnography where it can fall back on corroborative archæological and historical research, can validly be applied to a continent so deficient in such research.

G. I. JONES

FRONTIERS OF ORGANIC CHEMISTRY

Progress in Organic Chemistry, 1

Editor: Prof. J. W. Cook. (Progress Series.) Pp. viii+287. (London: Butterworths Scientific Publications, Ltd., 1952.) 50*s*. net.

A GLANCE at the current journals of the chemical societies of the world will show that organic chemistry remains an immensely fruitful and popular branch of science. A correspondingly heavy burden is placed on organic chemists and others concerned in keeping afloat in the cataract of literature. Fortunately the position is relieved by the increasing tendency to publish reviews of comparatively small sections of the subject. Among such reviews the collection of monographs entitled "Progress in Organic Chemistry, 1" is among the most authoritative.

Eight articles are included, all written by active workers in the different fields. To attempt a brief classification: four deal with natural products (Sir Robert Robinson on strychnine; H. Erdtman on heart-wood constituents; H. H. Brockmann on photodynamic pigments; I. A. Preece on starch); two deal with general synthetic and industrial organic chemistry (S. F. Birch on petroleum chemicals; B. C. L. Weedon on acetylene chemistry); one deals with reaction mechanisms (D. H. Hey on free radicals as intermediates); and one with chemotherapy (F. Bergel and A. S. Parkes on drugs inhibiting symptomatic stimulators). As might be expected from this list of authors, the general level of the contributions is remarkably high. It is of particular value to have from the highest authority a logical summary of the elucidation of the tangled structure of strychnine, coming as it does immediately after the final solution. Among the other monographs one notes particularly those of Erdtman and of Brockmann as authoritative reviews of most interesting groups of compounds. Bergel and Parkes's article is remarkable for its range, and Birch's for its timeliness.

A readable book of less than three hundred pages dealing with progress in organic chemistry can only touch on a few topics, and Prof. J. W. Cook has done well to limit these so that the treatment may be thorough. Nevertheless the book as a whole suffers from the defects of its qualities: it admirably describes *examples* of progress rather than the progress as a whole. It is probably true that the subject is now so wide that it can only be reasonably covered by a number of volumes like this, each dealing with one important aspect, such as natural products, synthetic methods, reaction mechanisms and so on.

The book is well printed and free from errors.

R. P. LINSTEAD

IONIZATION, *p*H AND BIOLOGICAL ACTIVITY*

BIOLOGICAL activity is known to be influenced by many physical and chemical factors; of these the degree of ionization is recognized as outstandingly significant. A change in biological response has often been observed to accompany a change in the degree of ionization of a drug, or of its biological receptor. Many common drugs, and other biologically active substances, are capable of undergoing this change in ionization somewhere within the physiologically interesting *p*H range. This would not be significant if both the molecule and the ion had the same biological action; however, in all cases that have been investigated, ions and the corresponding neutral molecules have been found to behave differently.

Chemistry of Ionization

With few exceptions, salts are completely ionized when in solution, and thus they can have no biological properties other than those of the individual ions of which they are composed. This simple conception is not always recognized by biological workers.

Unlike salts, acids and bases need not be completely ionized in solution. Strong acids and strong bases (for example, sodium hydroxide and hydrochloric acid) are completely ionized in the *p*H range of 0–14, but many biologically active substances are weak acids or bases and thus show variable ionization within this *p*H range. The degree of ionization in solution depends on only two factors, the *p*H and the pK_a. The latter is a constant for any acid or base, and thus, if the *p*H is controlled, the degree of ionization depends only on the nature of the acid (or base) being investigated.

By application of the law of mass action to the ionization of weak acids we obtain a quantity known as the acidic ionization constant (K_a), sometimes, but not so correctly, called the 'dissociation constant'. The degree of ionization of weak bases also can be described by acidic ionization constants. These ionization constants are small and inconvenient figures, and it is usual to employ their negative logarithms which are known as pK_a values. Thus, pK_a values provide a convenient way of comparing the strengths of acids (and of bases): strong acids have low pK_a values, strong bases have high ones.

An acid or base when half-ionized has a *p*H equal to its pK_a. On passing from a *p*H value which is one unit on one side of the pK_a to a *p*H value one unit on the other side, a given drug is converted from a substantially ionized to a substantially non-ionized condition. Hence, quite small changes in the *p*H of a solution can produce large alterations in the degree of ionization of a drug, and this may well result in a modified biological effect.

Influence of Ionization on Biological Action

The organic chemist frequently finds that chemical reactivity depends upon the degree of ionization. For example, dimethylaniline normally nitrates in the *ortho* and *para* positions; but if sufficient concentrated sulphuric acid is present for the substance to be entirely converted to the cation, the nitration occurs exclusively in the *meta* position. Similarly, the degree of ionization can influence biological action.

The ready reversibility of drug action by dialysis indicates that the drug and receptor appear to be held together by readily breakable bonds (for example, ionic bonds but not covalent bonds). Hence changes in the *p*H of the medium bathing a receptor, or use of an analogue of the drug with a different pK_a, might be expected to bring about a change in biological response in many cases.

Adsorption at surfaces is a second method by which ionization can affect biological action. Ionization is usually unfavourable to non-specific adsorption, where the neutral molecule is adsorbed and the more highly hydrated ion tends to remain in the water. On the other hand, specific adsorption, which depends upon the drug being complementary in shape or charge to the receptor, may favour preferential adsorption of the ion.

The degree of ionization can also influence greatly the ability of a drug to penetrate natural membranes. In general, the ionic form of a substance penetrates membranes much more slowly than the neutral molecule, as the ionic group is held by unlike charges on the outer surface of the membrane and repelled by like charges. However, certain ions, such as those of sodium and chlorine, appear to penetrate by special mechanisms, and the penetration of ionic drugs can often be assisted by the addition of lipophilic substituents such as chlorine or alkyl side-chains.

The action of a drug obviously depends not only upon its ability to combine with some vitally important substance in a certain tissue, but also upon the ability of the drug to reach that tissue. Many important drugs have a pK_a between 6 and 8, and this means that, at the physiologically important *p*H of 7, the drug is always in equilibrium with at least 10 per cent of its ionic form. Such drugs can pass through a membrane which would exclude ions, and yet they can regenerate some ions (by mass action) on the far side of the membrane.

It was once thought that the degree of ionization could not be of great importance in biology. It was considered that, as the biological receptors removed the toxic ionic species, more would be generated in accord with the law of mass action. However, many cases are now known where biological activity is highly dependent upon the degree of ionization. This indicates that the combination between drug and receptor is usually weak and completely reversible in nature. In a system in which a biological receptor is in equilibrium with a low concentration of a toxic ion and a high concentration of the corresponding molecule, a stability constant (K_s) can be assigned to the drug-receptor complex:

$$K_s = \frac{[\text{drug-receptor complex}]}{[\text{toxic ion}]\,[\text{receptor}]}$$

Thus the concentration of toxic ion in solution is controlled by this relationship, and it is also controlled by the ionization constant (K_a) of the drug. Where K_s and K_a are of similar magnitude, it is obvious that any deficiency of toxic ions in the solution will be replenished from the drug-receptor complex as easily as from the non-ionized drug. Under these conditions, the degree of ionization of

* Substance of three University lectures by Prof. Adrien Albert, delivered at University College, London, on October 13, 20 and 27.

the drug governs its efficiency; the greater the number of ions present, the greater will be the number forced into the drug-receptor complex. It must also be noted that the toxic ion may combine with non-vital groups, and this can lead to wastage of large quantities of the toxic agent.

The acridine antibacterials provide the best-known example of a positive correlation between ionization and biological activity. For example, only five different mono-aminoacridines can exist. Of these, two are highly ionized at *p*H 7 (5-amino- and 2-amino-), whereas the other three ionize to only a small extent. The two isomers which are well ionized have a powerful antibacterial action, whereas the three isomers which are poorly ionized have only a feeble action. The same correlation has been demonstrated in more than one hundred acridines, and, provided that the ionization is cationic and is not less than 50 per cent at *p*H 7·3, the chemical nature of the substituents in the acridine nucleus makes little difference. By examination of the effect of these antibacterial acridines over an extended *p*H range, a direct competition between acridine cations and hydrogen ions has been revealed. The simplest interpretation of this interesting fact is that some vital anionic group in the bacterium is blocked by combination with the acridine cation and is thereby prevented from discharging its normal metabolic function.

In certain cases, however, ionization appears to be disadvantageous to biological activity. For example, the action of salicylic acid, which inhibits cell-division in echinoderm eggs, has been shown to be strictly proportional to the neutral molecules present. Between these two extremes we also find a number of cases of biological action in which the molecule is more active than the ion, but in which the ion does show some activity.

Not only is the ionization of the drug important, but also the ionization of receptors. A biological receptor is regarded as a molecule, or portion of a molecule, the normal function of which in metabolism can be blocked by combination with an appropriate drug. There is evidence that receptors are often co-enzymes or the protein component of enzyme systems. The receptors which are relevant to the present discussion are those which can combine with drugs by ionic bonds, and which only ionizable drugs can block. The pK_a values of receptors cannot be predicted in advance of experiment, as their chemical nature is largely unknown.

Not all receptors are actually within the cell. For example, amœbæ are narcotized when undecane is injected into the external membrane, but not when it is injected into the amœba. The pK_a of a receptor which is on the outside of a cell can be studied by the response to drugs over a range of *p*H values, provided that the cell is otherwise unaffected by the *p*H range and that the ionization of the drug does not change within the range. It is known, for example, that the receptors for cationic antibacterials are on the outside of cells because the addition of lipophilic groups to the molecule does not increase the efficiency of the drug. Further, derivatives which yield 70 per cent of cation at *p*H 7 are no more active than those which yield almost 100 per cent. The point which must be borne in mind is that the receptor may be expected to change its degree of ionization as the *p*H is changed.

Ionization studies become more difficult when the receptor is within the cell. Very little is known of the *p*H within animal cells, and the results obtained from experiments with indicators must be treated with reserve. By an enzyme-activity method it has been shown that the *p*H within the cell, in at least one case, roughly corresponds to that of the buffer in which it is placed.

Thus it is desirable, in biological experiments, to work in buffer, which ensures that the drug is presented to the cell in a standard state of ionization, and also maintains, in a standard state, the mechanisms for the adsorption of the drug and its penetration into the cell.

Further Aspects of the Chemistry of Ionization

Many ionization constants vary with temperature. This effect is most marked with strong bases, which become much weaker as the temperature rises. Mention must also be made of zwitterions, that is, ionic forms which carry both positive and negative charges. Zwitterions are usually rather inert biologically; for example, histidine has none of the marked physiological properties shown by the corresponding cation, histamine.

A small potential has been found to exist between biological surfaces and water. This is the electrokinetic, or zeta, potential, and its existence has been held to imply that there must be a slight difference between the *p*H at the surface and the *p*H of the solution.

It has been found that some few cations are capable of combining with hydroxyl ions by means of covalent bonds to give non-ionized substances known as 'pseudo-bases', from which the original cation can be regenerated by acid. This reaction, unlike normal ionic equilibria, is rather slow, and it may require from an hour to a week for equilibrium to be achieved. It is impossible for the biologist to correlate ionization with biological response if pseudo-bases are involved, unless he has first ascertained the pK_a at equilibrium and the time taken to achieve equilibrium. The most common examples of pseudo-base formation are furnished by heterocyclic quaternary compounds and by triphenylmethane dyes.

A further example of ionization which must be considered is due to the thermodynamic activity effect. When anions and cations are present in concentrated solution, they tend to form ion-pairs and thus behave as though a small fraction of their total concentration were absent. This effect is reflected in pK_a values, both acids and bases appearing slightly weaker in strong solutions. Ions of formula weight more than two hundred have a greater tendency to form ion-pairs than simple ions and thus show considerably greater activity effects, that is, the proportion of free to bound ions becomes very low. Drugs which are desired to provide a depot effect, for example, globin-insulin and procaine penicillin, can be formed by combining a therapeutically active ion with an oppositely charged ion, both being of fairly high molecular weight. Such compounds are slow to release curative ions because of their large thermodynamic activity effect.

Organic molecules having two neighbouring groups, one an anion and the other an electron donor such as a nitrogen or oxygen atom, can form chelate compounds with metallic ions. These are essentially salts the activity of which is maintained far below their concentration, and metallic complexes of this type play an enormous part in biochemical processes.

It will be apparent from this discussion that knowledge of the ionization constants of biologically important substances is of great importance to the biologist. This information allows one of the most common variables to be brought under control and thus can add greatly to the scientific knowledge derivable from a biological experiment.

H. C. S. Wood

COMPARATIVE PHYSIOLOGY OF MUSCLE

On September 5 at the British Association meeting in Belfast, Sections D (Zoology) and I (Physiology) held a joint half-day session on the comparative physiology of muscles, under the chairmanship of Prof. R. C. Garry, president of Section I. The meeting was well attended, and it admirably fulfilled the two purposes of presenting part of an important modern field of research to non-specialists, and of providing a meeting ground for research workers concerned with different aspects of the behaviour of muscles. At the end of the morning, Prof. Garry commented on the success of the discussion, saying that this joint meeting of the two Sections had shown the importance of research into comparative muscle physiology, and the importance of considering structural changes at the same time as investigating the more physiological aspects of muscular contraction.

The discussion was introduced by Prof. A. V. Hill, who briefly reviewed the features that appear to be common to all contractile tissues, and their specializations for different purposes. He then directed attention to the important results, now published[1], which Dr. T. Weis-Fogh has recently obtained on the metabolism of flying locusts. Measurements of the amounts of fat and glycogen in the body before and after tethered flight indicate that migrating locusts (*Schistocerca gregaria* Forskål) are mainly dependent on fats for the fuel to sustain long periods of flight. Thus their flight muscles appear to be atypical: carbohydrates are generally considered to be the fuel used by most muscles. Locusts probably deplete most of their reserves of muscle glycogen during the 'warming up' activity preceding each day's flight; and when migration begins, they have mobilized other fuel reserves held elsewhere in the body, especially the fat in the fat bodies. Dr. Weis-Fogh has pointed out that the hydration of stored glycogen makes it about eight times heavier than isocaloric quantities of fat. Fats are thus very suitable food reserves for animals that fly for long periods, provided that they can be mobilized, and provided that the muscles have an adequate supply of oxygen. It is calculated that migrating locusts must eat at least one and a half times their own weight of food each day. A large swarm, weighing 13,000–19,000 tons, uses 500–800 tons of fat for its daily flight, and needs to consume a quantity of food that would supply one and a half million human beings with the calories they need each day. The metabolic rate of the flight muscles of locusts is very much higher than that of other striated muscles: for example, 400–800 kcal./kgm./hr. for locusts, as compared with 50–60 kcal./kgm./hr. for human leg muscles. Flies and bees and other insects have even higher metabolic rates, but their muscles use carbohydrates. It appears that many other muscles, not only those of locusts, are able to use fats as well as carbohydrates, but this faculty is especially highly developed in locusts. These specializations in muscle metabolism may ultimately be dependent on specializations in the enzyme systems of the muscle mitochondria.

Mr. J. Lowy (Laboratory of the Marine Biological Association, Plymouth) presented the results of his work on the smooth muscles of bivalve molluscs, particularly of the mussel *Mytilus edulis*. These animals, in their natural environment, are exposed to the air for long periods when the tide is low, and although the elastic ligament at the hinge of the shell tends to make the two valves gape apart, closure is maintained by the adductor muscles. Mr. Lowy's work has indicated that the adductor muscles can maintain a state of active contraction throughout long periods, and that it is probably unnecessary to postulate a special 'catch mechanism' in these muscles to account for their ability to maintain prolonged closure of the shell. Simultaneous recordings were made of shell movements and of the electrical activity in the posterior adductor muscle, both when the animals were exposed to the air (shells closed) and when they were in sea water (shells opening and closing at irregular intervals). Records of action potentials, some of them as large as 100 μV., were obtained not only when the muscles were contracting to close a gaping shell, but also throughout long periods of as much as two hundred hours when the shell was kept closed and the animal out of water. That the records of electrical activity pertain to the muscles and not to the nerves is suggested by the results of experiments on nerve-muscle preparations made from the pedal retractor muscle and pedal nerve of *Mytilus* and the anterior adductor muscle and its motor nerve in *Mya arenaria*: the electrical activity recorded from these muscle preparations when they were indirectly stimulated was similar to that recorded from these muscles or from the posterior adductor muscle of *Mytilus* during spontaneous activity, and it was dissimilar to that recorded from the nerves. It was also shown that there are no intramuscular nerve cells. It therefore seems to be clear that both intermittent and prolonged closure of the shell is brought about by typical contractions of the adductor muscle fibres.

Mr. Lowy has also found that electrical activity in the posterior adductor muscle ceases when the visceral ganglia are extirpated, although it continues if the visceral ganglia remain in place but the pallial nerves and the cerebro-visceral connectives are cut. These experiments suggest that nerve elements in the visceral ganglia are responsible for maintaining contraction of the posterior adductor muscle, and other experiments suggest that the visceral ganglia are also concerned in the initiation of relaxation. Relaxation could be brought about by appropriate tactile stimulation of the visceral ganglia, or of the mantle edge or cerebral ganglia. In some cases relaxation was accompanied by electrical activity in the adductor muscles, but in other cases electrical activity was suppressed while the muscles were relaxing.

The neuro-muscular mechanism of the insect leg was the subject discussed by Dr. G. M. Hughes (Department of Zoology, Cambridge). Most of his observations have been made on cockroaches. Analysis of cinematographic records of walking and running cockroaches shows that these insects modify their gait according to their speed; but both speed

and gait change gradually, and there is no sharply defined change-over from walking rhythm to running rhythm. Records of the electrical and contractile activity in isolated preparations of the flexor muscle of the tibia have led to the conclusion that the individual muscle fibres have a multiple innervation and can contract at different speeds. There are at least three different patterns of action potential records, correlated with different speeds of contraction. It is suggested that changes in the number or type of nerves involved in stimulating the muscle fibres can produce changes in the speed of contraction of the fibres, and thus bring about the graded changes in the speed and gait of the whole insect.

Much can be learned about the performance of a muscle by finding what force it can exert in contraction, and by analysing the relationship between the force exerted and the velocity of shortening. The equation relating force to velocity is

$$(P + a)(V + b) = \text{constant} = (P_0 + a)b,$$

where P is force, V is velocity, a and b are constants, and P_0 is the force exerted under isometric conditions, that is, where velocity is zero. A. V. Hill has shown that this equation not only fits the force–velocity curve but also expresses the way in which heat is emitted during contraction. It is therefore important to find how far different kinds of muscles and the muscles of different animals have mechanical properties which can be expressed by this equation. B. C. Abbott and D. R. Wilkie (Departments of Biophysics and Physiology, University College, London) have studied this question. Their experiments were made on isolated muscles from snails, dogfishes, rays, tortoises, frogs and toads, and results have also been obtained for human muscles by experiments on intact subjects. In all these muscles the tension developed during isometric contraction depends on the length at which the muscle is held, being greatest at about the length the muscle has in the body. During isotonic contraction, the greater the weight that the muscle has to lift the smaller is the amount of shortening. The velocity of shortening is greatest when the weight is least, and the equation relating force to velocity is the same for all the muscles investigated. The most striking difference found was in the maximal velocity the muscle could attain: this varied over a sixty-fold range from snail to man.

In the last paper, Dr. E. Jean Hanson (Medical Research Council Biophysics Research Unit, King's College, London) dealt with two aspects of muscle cytology relevant to comparative studies of muscle physiology. The cross-striations of isolated vertebrate and insect myofibrils have been studied in positive phase-contrast illumination, in polarized light and in the electron microscope. Isolated fibrils have been induced to contract by treatment with adenosine triphosphate, and the process of contraction has been watched in the microscope and the changes in the pattern of cross-striations studied. The conclusion has been reached that a material, provisionally called the 'A substance', which is segregated in the isotropic bands of relaxed fibrils, migrates during contraction along the long axis of the fibril, and most of it comes to lie in a set of new bands, the contraction bands, at the end of contraction. In spite of this change in the distribution of materials, the alternation of anisotropic and isotropic bands along the length of the fibril remains unchanged, and the factors responsible for birefringence are unknown. Contraction of myofibrils induced by adenosine triphosphate is irreversible, but there is reason to suppose that in other respects it is similar to normal contraction and that a migration of the unknown 'A substance' takes place when a muscle contracts *in vivo*. Finally, some observations on the smooth muscles of molluscs and annelids were briefly reported; the muscles investigated included those discussed earlier in this meeting by Lowy, Abbott and Wilkie. Fibres of these invertebrate smooth muscles, unlike the fibres of striped muscles, contain large quantities of proteins of the paramyosin type, about which little is yet known. Whereas a striped muscle fibre consists predominantly of actin and myosin, the two structural proteins concerned in contraction, molluscan and annelid smooth muscles have complex fibres consisting both of contractile myofibrils and of bundles of paramyosin or related fibrils. These bundles are responsible for the characteristic double oblique striation of these fibres. Paramyosin is very unlikely to be contractile, and it may be mainly responsible for many of the peculiar properties of these smooth muscles, for example, their extensibility and 'viscosity'.

[1] *Phil. Trans. Roy. Soc.*, B, **237**, No. 640 (1952).

CLASSIFICATION OF THE FUNGI

LIEUT.-COLONEL R. B. SEYMOUR SEWELL took the chair at the meeting of the Linnean Society on October 23, when a discussion was held on the "Classification of the Fungi".

Dr. B. Barnes said that the lower fungi, or Phycomycetes, are a heterogeneous group, separated from the other fungi by the usually cœnocytic vegetative body. This may be a rounded or lobed sac, a branched structure of characteristic shape, or, in the higher forms, a spreading mycelium. Septation in the vegetative body usually accompanies the formation of reproductive organs. In origin, septation may have been associated with the production of reproductive structures carried above the bacterial slime on the submerged substrata inhabited by many of these fungi. It seems likely that, during the course of evolution, septum formation has moved backwards in ontogeny; in some existing species, septate vegetative bodies occur in juvenile specimens. The septate vegetative body may well be in a physiological condition intermediate between that of the vegetative state and of the reproductive state.

Phycomycetes show some peculiar features distributed rather haphazardly among the members of the group, features scarcely of adaptive significance and more probably inheritances from the remote past. Notable among these features are: the persistent empty wall of the zoospore, the occurrence of two phases of motility with differences in morphology of the zoospore (diplanetism), and the assumption of amœboid characters by the zoospore. These features occur chiefly in a number of the Chytridiales and the Saprolegniales. From these two stocks, rather vague connexions may be traced to the other alliances of the Phycomycetes.

The Monadineæ Zoosporeæ occur as parasites or as saprophytes in algæ, fungi and bryophytes, and probably as common saprophytes in the soil. They are very simple, and can scarcely be regarded as

fungi, though in life-history and in organization they agree well with the simpler members of the Chytridiales and Saprolegniales. They differ in the tardy formation of a wall around the trophic body and in the ingestion of solid food with the ejection of solid residues of digestion. In the Monadineæ Zoosporæ and in the Phycomycetes, series may be traced, characterized by uniflagellate, biflagellate and non-flagellate spores: this appears very significant. Some of the Monadineæ Zoosporeæ leave persistent empty zoospore walls, and some show signs of diplanetism; amœboid stages are common. These points also are significant. Many members of the group are very common and they deserve more study than they have yet had. If this shows that features of life-history and behaviour are common to some of the simplest organisms yet known, and to the Phycomycetes, it must follow that the fungi are not plants, but lie on lines of development separate from those which run through the animals and the green plants. It must follow that the fungi are not decolorized algæ. Such research must be directed to the tracing of tendencies, and not to an effort to show that an existing species or genus is ancestral to, or derived from, another existing species or genus.

Dr. E. J. H. Corner pointed out that the purpose of classification is the identification of organisms and the recognition of their positions in an evolutionary system. Artificial systems frustrate research. Classification is concerned with genera, tribes and families. Speculation about phylogeny is an essential part of the work, for speculation is the ignition of taxonomy.

The classification of the higher Basidiomycetes is very backward. It is too artificial to stimulate research, and too inaccurate to permit the reliable identification of the organisms. The physiology, genetics and ecology of the higher fungi must be brought into the account, for these are living topics.

The higher fungi have a mycelium and a fructification. The mycelium is too generalized to be of use in classification; it is very uniform, and doubtless very efficient. The fructification must be used. What is a mushroom? It is a precise device for the production and liberation of spores. The gills are put out of action when they are immersed in water, and the basidia collapse; therefore, drawings of basidia are usually artificial. The mushroom is an umbrella which protects the gills from rain but maintains humidity around the spores; the polypore is a bracket which acts similarly. In contrast, the discomycetous apothecium is a cup which holds water.

Clavaria has no protection for its spores, and shows the primitive arrangement. A survey of the world flora of clavarioid fungi shows that they contain at least six natural series of genera or groups of genera. The Clavariaceæ, as currently understood, is therefore an artificial assemblage. There is a set of tropical Clavariaceæ which shows a general agreement with the polypores. A great group of species, with yellow-brown fruit bodies, cuts right across the accepted lines of classification, and contains clavarioid, stereoid and hydnoid forms. In some members of this group, the hyphal walls thicken early. This hinders growth, and would prevent the development of a fructification of mushroom type, for that depends on thin-walled hyphæ.

The genera of the higher fungi need to be dissected out into phylogenetic units. For example, *Fomes applanatus*, *F. igniarius* and *F. fomentarius* look much alike; but microscopic analysis shows them to be very different. Use of the method of hyphal analysis will reveal many other examples, and may yield good evidence of relationships.

If *Clavaria* is primitive, the ends of the lines of development in the Gasteromycetes are doubtless mixed groups. It seems certain that the resupinate Thelephoraceæ are to be derived along a number of lines of development within the Hymenomycetes; even *Pterula* may have resupinate fructifications.

Dr. J. Ramsbottom said that the objects of classification are the identification of organisms and their arrangement in a scheme showing relationships; differences in physiology and in chemistry must be taken into account. Schemes of classification based on presumed affinities may be valuable aids to identification, just as are artificial keys, though these can be deceptive because they often give meagre details. In large herbaria, an artificial scheme can be justified on grounds of convenience; even an alphabetical arrangement can be defended.

Morphological characters may be of little use, as in the yeasts, where it has been necessary to use the methods developed by the bacteriologists in classification.

Fungal cultures often produce saltations, mutations and strains, and these new forms may remain constant in subsequent cultures. Parasitic fungi, such as the rusts, have biological races, which may arise by mutation or by natural hybridization. Some of the biological races of *Puccinia graminis* are very virulent. Natural or induced variation has been of great importance in the production of penicillin. After the Americans had found that *Penicillium notatum* would not grow in submerged culture, they found a good strain on a rotting melon, and improved it by treatment with X-rays and other means. These strains and biological races cannot be neglected by the taxonomist, if only because of their economic significance. Experience gained during the search for antibiotics has shown that the fungi cannot be classified on their products; mycology and biochemistry are not synonymous.

Attempts have been made to identify toadstools by the use of sulphovanillin and other chemicals; but such tests have not been used with discrimination. Nothing seems to be known of the results of applying these chemicals to the same species at different stages in development. The tests are crude, and they are not critical.

Little is known of natural variation in the fungi. *Laccaria laccata* is well known to vary greatly; but is it variable because it is common, or common because it is variable? *Armillaria mellea* is variable; but little has yet been done on its systematics. It has forms with and without rings. In the old classification, the ring was held to be of great importance, and it is still held in respect. The old classification of the agarics was based on spore colour and on gross morphology. It is quite artificial, but we must continue to use it, for there is nothing to replace it. The logical method would be to associate all species with comparable developmental histories, no matter what the spore colour or the arrangement of the gills. Spore-sculpture needs much more study, as has been pointed out by some French workers.

Most of the phylogenetic schemes proposed for the higher fungi are of no importance; they may be described as "evolution in our time". Certainly, fungi are not decadent algæ.

Much more detailed knowledge is required before good theoretical schemes can be constructed. Even

before the idea of evolution was accepted, mycologists had recognized circles of affinity within the fungi. Evolution cannot be both the key to the problem and also the lock. A study of phylogeny may indicate what forms are primitive, and these are probably the simplest. But the evolutionary history of the higher fungi is still a mystery. A study of fairy rings suggests that the mycelium is much more important in reproduction than is the spore, and yet we have elaborate and extremely fertile fruit bodies.

Microscopic characters are of great significance in dealing with species, and hyphæ, as in the strands of *Merulius lacrymans*, may show much diversity of structure; they may have taxonomic significance. Biological characters must not be stressed too much. For example, the predacious fungi show a general and similar pattern of behaviour, but the predacious habit is to be found among Phycomycetes, Basidiomycetes and Hyphomycetes. B. BARNES

ASH AND CLINKER IN INDUSTRY

By T. F. HURLEY, O.B.E.

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DURING October 28–29, a conference described as "A Special Study of Clinker and Ash in Industry" was held by the Institute of Fuel at the Institution of Mechanical Engineers. Twelve papers were discussed which covered the origin and nature of the mineral matter in coal; its laboratory examination; the extent to which it is responsible for atmospheric pollution; the methods by which it can be removed either from the coal itself or from the products of combustion; and its effect upon the utilization of coal in various types of industrial plant. The papers had been published in advance in the *Journal of the Institute of Fuel*, and the Institute hopes to publish the text of the papers and discussions in the near future (£1 1*s*.).

In the field of utilization, small industrial boilers, gas producers, steel works plant, and, looking ahead, the industrial coal-fired gas turbine were considered, but most attention was devoted to the large water-tube boilers used by the British Electricity Authority, which is the largest single user of coal. This one organization now consumes 35 million tons of coal per annum, and as the average ash content of the rough slack supplied to it is about 15 per cent, it has to deal with about 5 million tons of ash per annum. Merely to handle this quantity of waste material is a formidable task, but during recent years the problems associated with ash and clinker have been further increased as a result of the present tendency to generate electricity in mammoth power stations employing very large and costly boilers working at extremely high temperatures and pressures. Among other consequences, the size of the stations requires more elaborate and expensive plant to avoid excessive atmospheric pollution in their vicinity, the higher temperatures in the boilers lead to a more objectionable type of deposit upon the heating surfaces, and to take one of a small number of very large boilers off the line for cleaning out of its turn affects materially both the output of the station and the cost of the electricity generated.

Taking industry as a whole, the importance of ash is steadily increasing as a result of changing mining conditions, which have led to more and more mineral matter being included in the coal brought to the surface. Various reasons were given at the Conference, the chief of which were, first, that the better seams have been worked out and those now being mined not only contain more ash but also include more dirt bands; and, secondly, increased mechanization causes more dirt to be mined and at the same time reduces the quantity which can be removed from the coal underground. Excluding 'free dirt', British coal seams still contain on the average only 5·5 per cent of ash and probably compare favourably in this respect with those of other major coal-producing countries; but for the reasons given, run-of-mine coal now includes on the average about 15 per cent of free dirt. This represented about 33 million tons of the 'raised and weighed' output for 1950.

It is obvious that the cost of mining dirt and bringing it to the surface is comparable with that of winning coal; but no suggestion was made at the Conference that the quantity of dirt brought to the surface could, or should, be reduced. In fact, a future increase in the ash content of coal was accepted as natural and inevitable.

Ash costs just as much as coal to convey from the pit head to the point of utilization, and at each stage beyond that it is a costly nuisance. Again taking modern power station practice as an example, ash costs more to pulverize than coal and it causes more wear in the machinery; it affects adversely the efficiency of combustion; it requires the size and therefore the capital cost of the boilers to be larger and at the same time it increases the difficulties of design and operation; it necessitates the provision of ash-handling equipment comparable in size and cost with the boilers themselves; some of it forms objectionable deposits which reduce both the efficiency and the availability of the boiler; it requires the installation of expensive dust collectors to minimize atmospheric pollution and, even when it has been collected, its disposal is a major difficulty.

Many, but not all, of these effects can be reduced materially by using known methods of cleaning the coal at the pit, but this involves a high cost in capital equipment, power and labour. So recently as 1950 the National Coal Board asked in its annual report whether "it may sometimes not be more economical to save some or all the cost of coal preparation at the price of reduced efficiency in the final stage of conversion". To this question the National Coal Board itself now appears to provide its own answer by stating that when all the cleaning plants ordered between vesting date and the end of 1951 are in operation, they will deal with about 42½ million tons of coal per annum. More than 100 million tons of coal are already cleaned mechanically each year.

On the other hand, the Conference showed that there is considerable divergence of opinion with regard to the extent to which it is economical to wash coal instead of dealing with the ash during utilization. This lack of agreement may arise from the wide variations which occur in the chemical composition of the mineral matter in coal and in the manner in which it is associated with the coal substance. Both the ease with which coal can be cleaned and the influence exerted by a given quantity of ash upon different industrial processes are affected by these variations.

Most coal-cleaning processes are based upon the difference between the specific gravities of coal and dirt, and some are capable of making a close 'cut' at

any predetermined density. When, therefore, the material to be cleaned consists partly of coal particles containing little dirt and partly of dirt particles containing little coal, it is easy to separate it into 'clean' coal and 'pure' dirt. On the other hand, when the coal substance is 'intergrown' with mineral matter, the yield consists of three fractions: relatively clean coal, middlings and dirt. The washery manager then has to balance the overall cost of cleaning against the requirements of his market and to decide what proportion of ash he should allow to appear in each fraction—a task requiring great skill and experience.

With these broad principles in mind, the general opinion of the Conference appeared to be that in present circumstances the more easily cleaned coals should be washed, and the dirty coals, middlings and even the refuse should be burned in the colliery boilers or in power stations erected in the vicinity. Plant is already being installed to burn what would formerly have been regarded as waste material.

The quantity of ash in the coal most easily supplied to a particular industrial plant may well determine the type of combustion appliance to be employed. Thus a chain-grate stoker would not usually be used with coal containing more than about 15 per cent of ash, whereas pulverized fuel containing more than 25 per cent of ash can be used in large boilers. On the other hand, it is very difficult to collect and dispose of the large quantity of fine ash made from pulverized fuel.

The composition of the ash has an equally important bearing upon the type of equipment to be used. Thus, boilers fired with pulverized fuel are usually immune from troublesome bonded deposits; but severe deposits frequently occur in boilers fired with mechanical stokers when the coal contains relatively small quantities of chlorine (more than 0·3 per cent), sulphur (more than 1·8 per cent) or phosphorus (more than 0·03 per cent).

In the same way, the amount of iron in the ash influences its tendency to fuse and form clinker or slag in the furnace. In most cases this is a source of trouble; but in some modern designs the ash is fused deliberately to enable it to be disposed of more easily.

For control purposes, it is obviously desirable to be able to predict the clinkering properties of an ash by a preliminary laboratory examination; but this is rendered difficult by the fact that when the mineral matter in coal is heated it changes its composition in a manner depending on the conditions of heating. In addition, the distribution of its constituents in a finely divided laboratory sample is different from that in the original lump coal. It is, therefore, impossible to devise one laboratory test for ash fusion temperature which would simulate all industrial conditions, and it is not surprising that varying opinions were expressed as to the practical value of ash-fusion temperatures determined by the standard method, which is necessarily empirical.

In spite of the variable nature of ash and its varying importance when coal is burned in industrial plant, it is clear that, if fuel is to be marketed on a national scale, a fair price can be assigned to any particular coal only after a quantitative allowance has been made for its ash content. Various methods of doing so were described, but every paper read could be used to illustrate the difficulty of devising a universal formula to meet all cases.

In general, the Conference showed that practical means have been found for dealing with the industrial problems associated with the presence of mineral matter in coal and that considerable knowledge is available concerning its nature and its behaviour in industrial plant. Nevertheless, the difficulties caused by it tend to increase, rather than to decrease, and there can be little doubt that they will continue to present major problems so long as coal is used as a fuel.

NEWS and VIEWS

Mineralogy at the British Museum (Natural History): Dr. W. Campbell Smith, C.B.E.

Dr. Walter Campbell Smith retired at the end of November from the post of keeper of minerals at the British Museum (Natural History) after forty-two years service. Joining the staff of the Department of Mineralogy in 1910, he became deputy keeper in 1931 and succeeded to the keepership in 1937. He was mainly instrumental in the expansion of the rock collections and in applying modern optical techniques to their identification and nomenclature. His well-known guide to the Museum's rock collections and his arrangement and labelling of them in the Mineral Gallery are models of clarity and accuracy, objectives no less difficult to achieve in petrology than in other sciences. Dr. Campbell Smith's numerous publications have included studies both in petrology and mineralogy, notably his pioneer investigations on hybridism in igneous rocks, his contributions on the petrology of rocks collected on famous expeditions such as the British Antarctic (*Terra Nova*) 1910, and his descriptions of new minerals from the manganese mine at Benallt, North Wales. He served as president of Section C (Geology) of the British Association in 1950, and on that occasion presented a survey of knowledge on the stony meteorites. During his keepership he was promoted to the post of deputy chief scientific officer (1948), and as deputy director of the Natural History Museum he found further scope for his interests in natural history. The knowledge that Dr. Campbell Smith will be able to continue his researches in his chosen field after his retirement will give much pleasure to his numerous colleagues and friends, both at home and abroad.

Dr. F. A. Bannister

Dr. Frederick Allan Bannister, who succeeded Dr. Campbell Smith on December 1, joined the British Museum (Natural History) staff on September 1, 1927, filling the vacancy caused by E. D. Mountain's appointment as lecturer at Grahamstown, South Africa. Dr. Bannister went from the Whitgift School, Croydon, to Clare College, Cambridge, in 1920. He won a Goldsmith Exhibition in 1921 and was placed in the first class in both parts of the Natural Sciences Tripos, studying physics under Rutherford and mineralogy under Hutchinson. After a year of research work under the direction of Sir Edward Appleton in the Cavendish Laboratory, Cambridge, he joined the Western Electric Co. in 1924, an experience which stood him in good stead in his later

work. In 1928 he spent a short time studying the methods of X-ray investigation of crystal structure under Sir William Bragg at the Royal Institution. On his return to the British Museum, Dr. Bannister set up apparatus for this work and very soon established a highly efficient laboratory in a partitioned-off corner of one of the rooms in the Department. This laboratory has been very active in the X-ray study of minerals and has a very high reputation for thoroughly accurate work among mineralogists at home and abroad. His lectures given at the Royal School of Mines in 1935 will still be remembered by those who were privileged to attend them. Dr. Bannister was honorary secretary of the X-ray Analysis Group of the Institute of Physics during 1945–48, and he attended the first general assembly of the International Union of Crystallography at Harvard in 1948 and the second assembly held in Stockholm in 1951.

A. A. Michelson (1852–1931)

ALBERT ABRAHAM MICHELSON, who was born a century ago, on December 19, 1852, at Strelno, in Prussia, near the Polish frontier, was perhaps the greatest authority of modern times on optics, and one of the most ingenious and accurate workers in experimental science. His family emigrated to the United States when he was two years old, and at the age of twenty-one he graduated from the United States Naval Academy, Annapolis, where he served as instructor in physics and chemistry during 1875–79. After studying at Berlin, Heidelberg and Paris, he held various posts before his appointment in 1892 as head of the Department of Physics at the new University of Chicago. His chief abiding interest was light, particularly the accurate determination of its velocity, and the study of optical interference. One of his greatest accomplishments was the construction of the interferometer known by his name, and among the many uses to which he put this instrument the most important were the determination of the international metre in Paris, the measurement of the angular diameter of a star, and the attempt to detect the relative motion of the earth in the ether. The negative outcome of the last-named experiment, carried out in collaboration with E. W. Morley, gave birth to a new philosophy of physical science, which culminated in Einstein's theories of relativity. With the aid of his échelon spectroscope Michelson examined the fine structure of spectral lines. The first American scientific worker to win the Nobel Prize for Physics (1907), he was a foreign member of the Royal Society and recipient of its Rumford and Copley Medals, and served on a number of international committees. He was a fine violinist and painter, and held that art finds its highest expression in science. He died of a cerebral hæmorrhage at Pasadena, California, on May 9, 1931, in his seventy-ninth year.

Antoine Henri Becquerel (1852–1908)

BORN in Paris a century ago, on December 15, 1852, Antoine Henri Becquerel came of a family long distinguished in the world of physical science. Educated at the École Polytechnique, Paris, his early studies were concerned with the magnetic rotation of the polarization plane of light, the influence of earth magnetism on the atmosphere, and the absorption of light by crystals. In 1892 he was appointed professor of physics at the Musée d'Histoire Naturelle—a chair held before him by his father, Alexandre Edmond Becquerel (1878), and by his grandfather, Antoine César Becquerel (1837). Three years later he became professor of physics at the École Polytechnique. His greatest achievement was the result of a lucky accident, but at the same time it was the culmination of a long series of carefully planned experiments. In 1896 he found that photographic plates, protected against ordinary actinic radiations, were fogged by emanations from uranium ores. His paper entitled "Sur les radiations émises par phosphorescence" (*C.R. Acad. Sci. Paris*, 122, 420; 1896) ushered in the new era of radioactivity. Their discoverer in 1903 shared the Nobel Prize for Physics with Pierre and Marie Curie, who in 1898 had isolated radium from pitchblende. Becquerel received the Rumford Medal of the Royal Society in 1900 and was elected president and permanent secretary of the Paris Academy of Sciences in 1908, and in the same year was elected a foreign member of the Royal Society. He died in Brittany on August 25 of that year.

Weights and Measures in Great Britain

A QUESTION regarding the report of the Committee on Weights and Measures Legislation (see *Nature*, July 28, 1951, p. 142) having been asked in the House of Commons, a written reply by Mr. Peter Thorneycroft, President of the Board of Trade, was published on November 11. Mr. Thorneycroft states that the Government is in general agreement with the decisions of Sir Hartley Shawcross announced on May 10 last year, and action has already been started on those recommendations which do not involve legislation. Referring to the metric system, he remarks: "The Government are not prepared to proceed with the recommendation for the eventual abandonment of the imperial for the metric system of weights and measures. Consultations with countries of the Commonwealth have, however, shown widespread support for the suggestion that a firm and legally defined relationship between the imperial pound and yard and the international metre and kilogramme should be established. On account of the wide variety of the recommendations and extensive nature of the consultations, the legislation will not be introduced for some time."

Higher Education in Central Africa

IN a written reply to a question in the House of Commons on November 26, the Secretary of State for the Colonies, Mr. Oliver Lyttelton, stated that the commission set up by the Governments of Northern and Southern Rhodesia and Nyasaland, in connexion with the establishment in Central Africa of a college for higher education for Africans, consists of Sir Alexander Carr-Saunders (chairman), Dr. A. Kerr, Dr. A. V. Hill and Prof. F. G. Young, with Mr. Walter Adams as secretary. The commission is now in Central Africa and its terms of reference include a review of the observations regarding the site of the college made by the committee appointed by the Central African Council, the making of recommendations regarding the site, type of courses to be provided and qualifications for admission, as well as on the type of buildings required. The commission is also to draw up a draft constitution for the college and to advise upon the form of 'special relationship' with an established university and on the staff required and its recruitment.

Current Literature relating to Scientific Instruments

THE British Scientific Instrument Research Association has issued monthly since 1946 a *Bulletin*,

which consists almost entirely of abstracts of any articles, papers, etc., connected with scientific instruments which appear in technical and scientific publications throughout the world. Of course, the abstracting service does not have a fixed and precisely defined subject-field, for the selection of material depends on, among other factors, the interests of the changing membership of the Association, the extent and availability of other sources of information, and the trends of interest revealed by inquiries made by staff who do the abstracting; consequently, a subject may be more fully covered during one period than in another. The *Bulletin* has grown with the years and has now achieved a reputation of filling a very real need and of doing so with considerable adequacy. Its functions are twofold, the first of which is to provide readers each month with a survey of current scientific publications on subjects of interest to them, and in this connexion it is best read like any other periodical review, that is, regularly and as soon after publication as possible. But it may not be realized in some quarters that, by virtue of its annual indexes, the *Bulletin* also serves as a permanent source of reference; indeed, the accumulated copies of the *Bulletin* and its indexes probably provide one of the easiest means of finding information which is related to scientific instruments and has been published within the past six years. All inquiries relating to these abstracts or to scientific instruments in general should be addressed to the Information Department, 'Sira', Southill, Elmstead Woods, Chislehurst, Kent (see also p. 1007 of this issue).

The Air Almanac

The British "Air Almanac" and the "American Air Almanac" have now become a single publication under the title "The Air Almanac", which will be published three times yearly, each issue containing the requisite data for four months. The first issue of this joint enterprise is for January–April 1953 (Air Publication 1602; pp. 242+56. London: H.M.S.O.; Washington, D.C.: U.S. Naval Observatory. 1952; 10*s*.). It is produced jointly by H.M. Nautical Almanac Office, the Royal Greenwich Observatory, and the Nautical Almanac Office, United States Naval Observatory, but it is printed separately in England and in the United States. Although the unification of the two former publications has necessitated a number of minor changes in both, these will be obvious to those who use "The Air Almanac", and navigators who have been familiar with either almanac will find no difficulty in using the new production. Very full explanations are given, and in order to make the almanac more satisfactory for international use a list defining the symbols and abbreviations that are used is given in English, French and Spanish. The International Civil Aviation Organization accepted the new publication as the basis of an international air almanac, and it seems probable that it will be reproduced, with language changes, in France. It is hoped that it will eventually become international.

Preservation of a Saxon Wooden Bucket

In the October issue of the *Museums Journal*, Dr. A. A. Moss, of the Research Laboratory of the British Museum, relates with illustrative photographs the remarkable achievement of the preservation of a Saxon bronze-bound wooden bucket with an iron handle. The bucket, when found in Wiltshire, consisted of water-logged staves of yew maintained in position by wet chalk. The four bronze bands were broken. The bucket was immersed in water to prevent shrinking and the chalk removed. The wooden staves were found to be very fragile and the bronze bands corroded. It was deemed necessary to take the bucket to pieces and treat the wood and bronze separately. The corrosion products were removed from the bronze bands and from the supporting strips by electrolytic reduction in a 5 per cent solution of sodium hydroxide. This loosened the rivets, which could then be easily removed. After soaking in water to free from chloride, the fractured edges were joined with soft solder. To preserve the shape of the wood it was decided to replace the water in the cells by alum. Eventually, after drying, the surface of the wood was painted with a dilute solution of cellulose nitrate. In re-assembling the wood and the bronze, a circular bottom for the bucket was made out of 'Perspex'; this fitted into the grooves in the staves. 'Durofix' was used for re-assembling the wooden portions.

The Post-fledging Dispersal of Juvenile Titmice

The post-fledging dispersal of juvenile titmice was studied by Ivan M. Goodbody in the summer of 1950 in a piece of mixed deciduous woodland near Oxford (*British Birds*, 45, No. 8; August 1952). 248 young bluetits and 191 young great tits were marked with a colour ring on each leg, so that all the birds hatched in the study area could be identified as such, wherever seen. Regular counts of the number of ringed and unringed tits were made in the study area and in a strip of woodland outside it, and showed that an explosive dispersal of young birds takes place within a week or two of leaving the nest; thereafter birds continue to move outwards from their birthplaces. A marked rise in the percentage of unringed juveniles both in the study area and in the outside area in mid-August indicates the possibility that there may be a passage of juveniles at about this time. While no ringed birds were found in a large woodland area one mile away, several were located in low-lying water meadows half a mile away.

Solanaceous Alkaloids in Normal and Grafted Plants

In normal plants of *Atropa belladonna* the ratio of hyoscine to hyoscyamine is approximately constant at a value of 0·12, irrespective of the total alkaloid present in the plant, the part of the plant analysed, or whether the plant is aged or starved. By contrast, in the normal plants of *Datura innoxia* this ratio is high (average 9·71; tap roots 13·81–17·36; other parts 4·6–9·8). In grafted plants the scion always contains the alkaloids in the proportions characteristic of the plant used as stock, not in those of the scion species. It thus appears that the alkaloids are synthesized in the roots, particularly in the young growing tips, and that they are transported unchanged, probably in the transpiration stream, into the shoot. These results have been obtained using partition chromatography, the extracts tested being of plants into which no foreign alkaloids had been introduced (see G. M. James and B. H. Thewlis, *New Phyt.*, 51, 2, 250; 1952).

A Lower Devonian Charophyte

A new species of *Trochiliscus* (Charophyta) from the Downtonian (Lower Devonian) of eastern Europe, described and illustrated by some good photographs by W. N. Croft (*Bull. Brit. Mus. Nat. Hist.* (Geology), 1, No. 7, 1952), probably affords the earliest reliable

record of an undoubted Charophyte. It is considered that this species was probably a land plant, growing like the recent and contemporary *Charas* in fresh and brackish water.

Central American Flora

THE very rich floristic region of Central America has long attracted taxonomic botanists. In a recent work ("Flora of Guatemala", by P. C. Standley and J. A. Steyermark. *Fieldiana:* Botany, 24, Pt. III, published by Chicago Natural History Museum, April 1952), the authors have dealt with the major monocotyledonous families from Commelinaceæ and Pontederiaceæ to Cannaceæ and Burmanniaceæ, and with dicotyledonous families including Casuarinaceæ and Piperaceæ to Fagaceæ and Urticaceæ. Some excellent line-illustrations accompany the text.

Sunspots during January–April 1952

AN account by Lucy T. Day of the positions, areas and counts of sunspots during the period January–April 1952 is given in United States Naval Observatory Circular No. 36 (June 18, 1952). The results, tabulated in seven pages of the Circular, are based upon measurements made at the Naval Observatory on plates secured there or at the Mt. Wilson Observatory, and are a continuation of those published in the *Monthly Weather Review* from February 1, 1927, to December 31, 1947. An explanation is given of the meaning of the various symbols used in the seven columns, and at the end of each month the mean daily area and the mean relative sunspot number are given.

Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have recently been announced: W. E. M. Logan (assistant conservator of forests, Kenya), regional assistant conservator of forests, Tanganyika; P. S. Hammond (agricultural officer, Gold Coast), assistant director of agriculture (cocoa industry), Gold Coast; J. B. D. Robinson (chemist, Department of Science and Agriculture, Barbados), scientific officer, agricultural chemist, Kenya; J. M. Waterston (senior botanist, Nigeria), principal research officer, Agriculture Department, Nigeria; G. C. Witt (soil survey officer, Trinidad), soil chemist, Trinidad; Dr. S. E. Piercy (senior veterinary research officer, Kenya), chief veterinary research officer, Kenya; J. F. C. Swan (senior veterinary officer, Northern Rhodesia), chief animal husbandry officer, Northern Rhodesia; S. B. Chambers (statistician, Nigeria), government statistician, Nigeria; H. A. Darby, R. E. Osborne and I. H. Tomlinson (agricultural officers, Jamaica), senior agricultural officers, Jamaica; H. C. Peisley (assistant government pharmacist, Fiji), government pharmacist and medical storekeeper, Fiji; G. E. Redshaw (agricultural assistant, Jamaica), agricultural officer, Jamaica; R. O. Williams (agricultural officer, Kenya), chief research officer, Agricultural Department, British Guiana; W. H. Andrews and D. A. L. Brown, agricultural officers, Tanganyika; R. E. H. Atkinson, agricultural officer, Uganda; A. M. Cockburn, agricultural officer, Nigeria; J. R. Dunsmore and M. J. Smith, agricultural officers, Federation of Malaya; J. R. Peberdy, agricultural officer, Kenya; J. W. Reed, agricultural officer, Nyasaland; E. A. Riley, plant pathologist, Northern Rhodesia; G. Fry and J. S. Spears, assistant conservators of forests, Kenya; E. Williams, geologist, Uganda; Miss H. G. T. Maycock, pathologist, Federation of Malaya; J. Riley, scientific officer (entomologist, W.A.P.I.R.U.), Nigeria; J. Smartt, plant breeder/scientific officer, Northern Rhodesia; M. C. Butler, veterinary officer, Kenya; R. H. Johnson, veterinary education officer, Nigeria; A. Beaton, assistant conservator of forests, Uganda; M. J. Berry, assistant conservator of forests, Federation of Malaya; B. M. Brown, meteorologist, West African Meteorological Service, Nigeria; J. A. Channon, meteorologist, East Africa High Commission; P. B. Cornwall, entomologist, West African Cocoa Research Institute, Gold Coast; H. F. Lamprey, biologist, Game Department, Tanganyika; W. McC. Lyall, field geologist, Kenya; P. F. Neal, field officer, Geological Survey Department, Uganda; C. J. Swanson, meteorologist, East Africa Meteorological Department, East Africa High Commission; D. C. Upton, statistician, East Africa High Commission; J. A. Willby, livestock officer, Tanganyika; A. C. Williamson, assistant conservator of forests, British Honduras.

Announcements

PROF. P. M. S. BLACKETT, Langworthy professor of physics in the University of Manchester, has been appointed to the University chair of physics tenable at the Imperial College of Science and Technology, London. The title of reader in organic chemistry in the University has been conferred on Dr. L. N. Owen in respect of the post held by him in the Imperial College.

PROF. JAMES CHESTER BRADLEY, professor emeritus of entomology, Cornell University, one of the United States representatives on the International Commission on Zoological Nomenclature since 1944, has been elected president of the Commission, in succession to the late Dr. James Lee Peters, Museum of Comparative Zoology at Harvard College, Cambridge, Mass.

SIR CHARLES DARWIN has been appointed chairman of the Radioactive Substances Advisory Committee in succession to Sir Henry Dale, who has resigned. Prof. G. R. Cameron (University College Hospital Medical School) and Prof. K. G. Emeléus (Queen's University, Belfast) have been appointed to the Committee.

THE fourth annual conference of the Society for the Study of Fertility will be held in the University of Liverpool during July 7–8, 1953. Further particulars can be obtained from the honorary secretary, Dr. G. I. M. Swyer, at University College Obstetric Hospital, Huntley Street, London, W.C.1.

AT a meeting of former members of the late Scottish Seaweed Research Association, those present determined to form a Society to be known as the Seaweed Utilization Society, to serve as a two-way channel of information and opinion with the Institute of Seaweed Research. The secretary of the Society is Miss M. D. Walker, 49 Rodney Street, Liverpool 1.

THE Oil and Colour Chemists' Association will hold its 1953 conference at Eastbourne during June 2–6. The general theme will be "The Optical Properties of Films of Surface Coating Materials", and there will be three technical sessions, each of three papers, on the mornings of June 3–5. Hotel reservations must be completed before January 1 on the appropriate form, obtainable from the general secretary of the Association at Memorial Hall, Farringdon Street, London, E.C.4.

APPLICATION OF RADAR TO METEOROLOGY

CONFERENCE IN MONTREAL

THE third Radar Weather Conference was held in the Macdonald Physics Laboratory of McGill University, Montreal, during September 15–17. About eighty people actively engaged in research into the application of radar to meteorological problems attended, and some forty papers were read and discussed in seven sessions. A very useful feature of the Conference, which contributed greatly to the value of the discussions that followed each paper, was the provision, before the beginning of the first session, of copies of all the papers scheduled to be read. When it is noted that the time-limit for receipt of authors' manuscripts was only three weeks in advance of the meeting, it is clear that Drs. Marshall, Gunn and Hitschfeld, of the Stormy Weather Research Group, McGill University, who formed the conference committee, accomplished a notable feat of organization.

The subject of Session *A*, under the chairmanship of Mrs. P. M. Austin (Massachusetts Institute of Technology), was "Precipitation Mechanisms". It is now more generally recognized that the Bergeron–Findeisen theory of rain formation—the rapid growth of ice crystals in an atmosphere saturated with respect to water, followed by growth by collision with cloud particles—is not adequate to explain all cases of rain formation, and that growth to raindrop size, without the aid of an ice crystal, by coalescence in the liquid state must also occur. The relative importance of each mechanism in a particular weather situation is, however, still a matter of speculation. That radar may be of great assistance in resolving this problem was shown in papers by Wexler (Massachusetts Institute of Technology), Battan (University of Chicago) and Cunningham (Massachusetts Institute of Technology). From data on the level at which radar echoes from thunderstorms first appear and their subsequent rate of growth, Battan concludes that rain formation in convective clouds, even those extending above the freezing level, may often occur through a process involving only the liquid phase. On the mechanism of this process, East (McGill) suggested that, if by some method—for example, turbulence or steady acceleration of the air—the gravitational field around a cloud droplet is increased, then the rate of growth of that droplet by collision with smaller droplets will also increase. Hence turbulence may play an important part in the generation of rain in cumulus clouds.

Turbulence as it affects aircraft rather than cloud droplets was the subject of a paper by R. F. Jones (Meteorological Office, East Hill). It was shown that the structure of the echo from a cumulus or cumulo-nimbus cloud, as seen on the radar display tubes, particularly in the vertical cross-section, is a useful guide to the severity of the turbulence likely to be encountered by an aircraft traversing the cloud and also indicates the places in the cloud where the turbulence is likely to be the most severe.

Marshall, Langleben and Rigby (McGill), from an examination of the characteristic 'mare's tail' radar echo-pattern (seen in the vertical cross-section) associated with falling snow, suggested that snow is generated continuously in compact generating elements rather than uniformly over a wide area.

Session *B*, under the chairmanship of Prof. H. Byers (University of Chicago), was devoted to "Cloud Observations and Cloud Radar Problems". Whereas radars operating on wave-lengths of 10 cm. and 3 cm.—the only wave-lengths commonly used for weather purposes up to this time—detect only those parts of clouds containing rain or drizzle drops or snowflakes and not the whole clouds, Plank, Atlas and Paulsen (U.S. Air Force Cambridge Research Centre), using a vertically-looking radar of wave-length 1·25 cm., reported that about 47 per cent of all clouds can be detected. Swingle (Signal Corps Engineering Laboratories), with a vertically-looking 0·86-cm. radar, has obtained better results than on 1·25-cm. wave-length on cumulus, cirro-stratus and cirrus clouds, and about the same results on other clouds. The results obtained are in accordance with the Rayleigh scattering theory, so that even these radars of shorter wave-lengths see only the parts of clouds containing the larger elements. Nevertheless, the ability to detect smaller droplets or ice crystals than with wave-lengths of 10 and 3 cm. will add further to the knowledge already gained of precipitation processes.

Session *C* was held in the Council Chamber of the International Aviation Building, with Mr. A. C. Bemis (Massachusetts Institute of Technology) as chairman. The purpose of this session was to bring together the radar meteorologists and those interested in the possibilities of using airborne radar to increase passenger safety and comfort. Carnes (Aeronautical Radio, Inc.) put the airline point of view, and pointed out that economical operation demands that the size and weight of electronic equipment carried must be kept small. He said that 3-cm. airborne radar suffers too much from attenuation in heavy rain, and a wave-length of 6 cm. is being recommended. Tolefson (National Advisory Committee for Aeronautics) showed that the use of radar will enable the pilot of an aircraft significantly to reduce the number of large gusts it encounters with increased passenger comfort, a finding which is supported by the work done in Britain. It is unlikely, however, that radar could assist in reducing the number of small gusts encountered, a factor of importance to structure fatigue.

"Rain Measurements" was the subject of Session *D*, over which Mr. D. Atlas (U.S. Air Force Cambridge Research Centre) presided. 10-cm. or 3-cm. radar has the useful property of indicating over a surrounding area almost instantaneously—in the time taken to sweep the radar beam over the area—the places where precipitation is occurring, and, from the intensity of the received radar signal, an indication of the rainfall intensity can be obtained. In areas where very heavy rainfall over the catchment area of a river leads to dangerous flooding farther down, the warning which radar can give may be of great value in saving lives and property. Research along these lines was reported by Stout and Neill (Illinois State Water Survey), who claimed that rainfall-rates computed from the received signal intensities of a 3-cm. radar were as accurate as those obtained from a rain-gauge network of 1 gauge per 200 square miles.

Similar results using 10-cm. radar, with a pulse integrator device which gives automatically the average signal intensity over an area, were reported by Austin and Richardson (Massachusetts Institute of Technology).

Mr. G. E. Stout (Illinois State Water Survey) presided over Session *E*, which was devoted to "Instruments". As well as the radars of short wave-length already referred to, which it is hoped to use as indicators of cloud base and top, instruments were described which are designed to measure rain-drop sizes and distributions from aircraft and on the ground. A knowledge of liquid water content and drop-size distribution is of importance in assessing quantitatively the radar signal received from a volume of cloud.

Dr. R. A. Smith (Telecommunications Research Establishment, Malvern) was chairman of Session *F*, when "Scattering in the Atmosphere" was discussed. Gunn and East (McGill) and Labrum (Radiophysics Laboratory, Sydney), working independently, have put on a firm quantitative basis the theory of back-scattering of radio energy from ice spheres coated thinly with water and from water spheroids. They have proved (what up to now has been assumed) that a small ice sphere with a thin water coating, as, for example, in the first stage of melting, will scatter nearly as well as a water sphere of the same volume and may absorb better. A water-coated ice spheroid may scatter and absorb very much more strongly than the spherical water drop into which it melts, giving an explanation of the well-known 'bright band' effect of enhanced echo at the freezing-level in conditions of continuous rain.

Gerhardt (University of Texas) said that his refractometer measurements indicated that in subsidence and frontal inversions the refractive index gradient over short distances may be several orders of magnitude greater than the normal, and that isolated patches exist with variations of refractive index adequate to explain 'angel' echoes (radar echoes received from a clear sky). Gordon (Cornell University) explained how scattering from turbulent patches in the atmosphere may increase the field strength beyond the horizon above the theoretical value at frequencies greater than 30 Mc./s., as has often been observed. There was some discussion on 'angel' echoes, which were reported by W. B. Gould (Signal Corps Engineering Laboratory) to have been observed in great numbers using a vertically-looking radar of wave-length 1·25 cm. These echoes are also observed in Britain using wave-lengths of 3 cm. and 10 cm. and are almost certainly associated with inhomogeneities in the atmosphere of the kind described by Gerhardt.

The final session, under the chairmanship of Dr. Gould, discussed "Fluctuating Signals", the object of this topic being to deduce some of the properties of the scattering particles by measurement of the fluctuations from pulse to pulse of a radar signal. In particular, it is hoped that the measurements may yield information on the turbulence within a cloud—for example, the size and duration of turbulent eddies. The subject is clearly complicated by the large distribution of drop sizes within a precipitating cloud and also by the inherent variabilities in the performance of radar sets.

Before finally dispersing, the Conference decided to accept an invitation to hold its fourth meeting during November 1953 in the University of Texas.

R. F. Jones

INTERNATIONAL SCIENTIFIC FILM ASSOCIATION

SIXTH ANNUAL CONGRESS

THE growing strength of the international scientific film movement was well in evidence at the annual congress of the International Scientific Film Association, held in the Maison de la Chimie, Paris, during September 23–October 1. During the congress, the acceptance of three countries as new members was announced—Cuba, East Germany and West Germany—and the reports from all countries showed steady progress and development in the use of the film for scientific education, for research and for popularizing science.

Seventy-two delegates and observers, representing twenty-one countries, the United Nations Educational, Scientific and Cultural Organization, the Federation Internationale des Archives du Film and the Federation Internationale des Ciné-Clubs, attended the congress. During the meeting, a hundred and seventeen films were shown to public and specialized audiences and, of these, the largest number from any one country was from Great Britain, no fewer than twenty-seven British films being shown; among them may be particularly mentioned "Atoms at Work", the Crown Film Unit's ten-minute documentary on Harwell, which attracted wide interest and resulted in a unanimous resolution by the congress urging other countries to give it the widest showing and to make similar films depicting their own development of atomic energy for peaceful ends.

Other films shown included a West German film illustrating, by means of infra-red photography, the remarkable fact that mice will fight savagely in the dark but never in the light; a French film showing the film work by the late Bernard Lyot on astronomy; a quite outstandingly beautiful Hungarian colour film of bird and insect life on the great lakes; an Icelandic film made by Mr. Tutte Lemco on the eruption of Mount Hecla, the dramatic shots of which provoked several bursts of spontaneous applause; and an equally striking Italian colour film of the courtship of the praying mantis.

The Research Section of the Association held several sessions, at one of which there was a demonstration of magnetic strip recording by M. André Didier, which was of particular interest to the British members present in view of its introduction at the present time into Britain. There were also two demonstrations of stereoscopic techniques. The first, by Dr. François Savoye (Paris), dispenses with 'Polaroid' glasses and relies on a synchronized rotating 'grill' in front of the screen to alternate the right- and left-eye images. It was effective, but suffered from the fact that the viewer's head has to be held very still in order to avoid a shifting of the images—a drawback that may possibly be due to the fact that both screen and grill were rather small. The other stereoscopic system was demonstrated by H. Dewhurst, of the Telecommunications Research Establishment, Malvern, using 'Polaroid' glasses and a beam-splitting equipment which is within the scope even of the amateur film-maker. The demonstration was mainly with an amateur colour film, and the results were excellent, although again handicapped perhaps by a small screen.

Among matters discussed by the general assembly of the congress was a proposal to establish a Section

of the Association to deal with veterinary science, a suggestion which was made by the Netherlands delegation and accepted by the assembly. It was also decided to consider the possibility of holding at the 1953 congress a special session on high-speed cinematography.

The officers of the Association elected unanimously for 1952–53 were as follows: *President*, John Maddison (Great Britain); *Vice-Presidents*, Jan Korngold (Poland) and Prof. Mario Ponzo (Italy); *Honorary Treasurer*, J. W. Varossieau (Holland); and *Honorary Secretary*, Jean Painlevé (France). In addition, Luc Haesearts (Belgium) was re-elected as curator of the International Film Reference Library and Prof. R. V. Talice (Uruguay) was appointed as delegate for Latin America; Dr. G. Wolf (West Germany) was elected chairman of the Research Section, and Prof. Dekking (Holland) chairman of the Medical Section.

Great Britain was represented at the congress by a strong delegation led by Dr. Malcolm Donaldson, which also included Prof. H. Dryerre, representing the Scottish Scientific Film Association. At the end of the final session of the Assembly, it was unanimously agreed to accept the invitation of the British delegation to hold the seventh congress in London during September 1953. J. Stewart Cook

INSULATION OF ELECTRICAL EQUIPMENT

A VACATION 'school' on the insulation of electrical equipment was held in the Electrical Engineering Department of the Imperial College of Science and Technology, London, during September 15–19. It was attended by some eighty engineers drawn from industry, the British Electricity Authority, research associations, technical colleges and the universities. The purpose of the course was to consider the factors which are limiting insulation design in the main classes of electrical equipment, and the general principles which should govern the approach to the solution of outstanding problems in this field.

An opening address was given by Dr. P. Dunsheath, chairman of convocation of the University of London, in which he commented on the value of postgraduate schools in facilitating and extending the interchange of knowledge and ideas between specialists of long experience and the more junior members of industry and in reducing the time-lag in the use of new information. He then drew on his long experience of cable manufacture in an interesting historical review of early developments in insulating materials and of the difficulties which were encountered and overcome when little was known of the principles underlying their behaviour.

In the first lecture Prof. Willis Jackson, of the Imperial College of Science and Technology, London, discussed the problems facing the insulation engineer, surveyed the historical development of the widely used materials based on natural products and of the more recent synthetic materials, and outlined the progress which has been made towards explaining the electrical, physical and mechanical properties of these materials in terms of their chemical composition and physical structure. He was followed by Dr. L. Hartshorn, of the Electricity Division, National Physical Laboratory, Teddington, who spoke on the phenomena of permittivity and dielectric loss, with particular reference to the effects on them of temperature, humidity and oxidation.

The third lecture, by Dr. S. Whitehead, director of the Electrical Research Association, dealt in a comprehensive manner with existing knowledge of the mechanisms of intrinsic and thermal dielectric breakdown, and of breakdown due to external or internal discharges. Dr. Whitehead also discussed the effect on the electric strength of electrochemical deterioration in service, and the scope for improvement in materials, design and testing. Another member of the Electrical Research Association, Mr. C. G. Garton, then spoke on the structural basis of electrical and mechanical properties, and gave a very illuminating treatment of rate processes in relation to the dependence of these properties on temperature and frequency.

In the fifth lecture Mr. R. Snadow, of the British Thomson-Houston Co., Ltd., reviewed the available insulating materials in terms of the present thermal classification. He emphasized the inadequacy of this classification for some of the new synthetics, and that their application is being retarded by too limited knowledge of their thermal endurance.

The next five lectures were concerned with the applications of insulation in different classes of electrical equipment, and with the design problems involved. In discussing communication components, Mr. I. M. Ross, of the Ministry of Supply, referred to the extremely wide frequency-range with which the communication engineer has to deal, and the severe thermal and mechanical conditions to which military communication equipment, in particular, is subjected. After reviewing the changes in design which the use of new synthetic materials has made possible during recent years, he outlined the directions in which further improvement is required. Dr. L. G. Brazier, of British Insulated Callender's Cables, Ltd., dealt with the development of high-voltage cables and remarked that, in consequence of improvements which have occurred in the qualities of paper and oil and in the methods of cable fabrication, the oil-paper dielectric introduced by Ferranti some fifty years ago remains the only form of dielectric suitable for use at the highest operating voltages. He outlined the outstanding problems and the methods being adopted to resolve them. The design of power capacitors, and the manner in which this might be affected in the near future by the use of the new ceramics based on barium titanate, was then discussed by Dr. R. S. Vincent, of British Dielectrics Research, Ltd.

Mr. E. Jones, of the English Electric Co., Ltd., made a comprehensive review of the insulation problems involved in the design of electrical machines and indicated possible lines of approach to a more efficient use of insulation, and the reasons why, except to meet special requirements, there is no great need for, nor likelihood of, a marked increase in operating temperatures. The subject of transformers was dealt with by Mr. D. McDonald, of the British Thomson-Houston Co., Ltd. After discussing the electrical, mechanical and thermal requirements of transformer insulation design and the problems involved in satisfying them, he illustrated the trends of high-voltage transformer design by consideration of the shielded cylindrical layer-type winding. He brought out the increasing similarities with cable construction and the movement towards the exclusive use at the highest voltages of the oil – paper dielectric. Mr. P. G. Ashley, of the Metropolitan-

Vickers Electrical Co., Ltd., then discussed the insulation of switchgear. He surveyed the main uses of insulation, for supports, fillers and coverings, and the suitability of available materials for these purposes and, after emphasizing the need for fuller information concerning the long-term stability of materials and the difficulties of obtaining it, concluded by remarking that technically, if not economically, 500-kV. switchgear is a feasible proposition.

The final lecture, by Dr. J. S. Forrest, of the Research Laboratories of the British Electricity Authority, was concerned with the testing of insulation in the laboratory, factory and field. He classified the tests in use according to their function and advised on the interpretation of test results; he emphasized the need for constant review of the methods of test directed towards the formulation of a scheme of testing which would reflect the service conditions to be met as faithfully as possible He remarked that such an approach would assist in improving the present inadequate correlation between laboratory, factory and field tests.

The specialized discussions which followed the individual lectures were supplemented by a general discussion during the final session, when attention was devoted to questions such as the availability of new materials; the inadequacies of the present classification; the much more satisfactory understanding of the electrical mechanisms of dielectric behaviour compared with those governing the physical and mechanical properties, and finally, the desirability of increased and more fundamental attention to materials in courses leading to degrees and national certificates in electrical engineering. Visits were made during the course to the laboratories of the Electrical Research Association and the British Insulated Callender's Cables, Ltd.

BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

OPEN DAYS

WITH whatever feelings one regards the advancing front of science, it is obvious that the operation of new processes and new techniques, which give force to ideas and actions based on them, is maintained and nourished by the development of scientific instruments. These are tools of industry as well as of research. Thus the practice of the art and craft of instrument-making is a key industry, and it is significant that the British Scientific Instrument Research Association was the first of the industrial research associations, being founded in 1918. The laboratories of the Association are situated near Chislehurst in park-like surroundings, and when members and friends were entertained there on the recent open days (November 5 and 6) the weather was mild and clement enough to reinforce the pleasure of the occasion.

For thirty years the work of the Association was carried on in a house in Russell Square, London, and was mainly concerned with the manufacturers of optical instruments. This is not the place to report on the vicissitudes and difficulties of the early years, but in the outcome there has been very considerable development. During and since the Second World War the membership has greatly expanded, as has the scope of the experimental work undertaken, and the facilities provided at Chislehurst are comprehensive and impressive. No great powers of observation are required by the visitor to confirm that the Association is an integral part of the scientific instrument-making industry.

Research associations, though having essential similarities, differ markedly from one another in a variety of ways which reflect the character, scope and state of scientific development of the industries which they serve. Some of them are able to concentrate on the behaviour and manipulation of narrow groups of raw materials or types of processes on which their industries depend. In this sense the field may be relatively narrow, or at least the boundaries may be reasonably well defined. The British Scientific Instrument Research Association must have a broader outlook, for it serves an industry which itself serves a great variety of other industries, and to these must be added the Armed Services, universities and scientific establishments of all kinds. In general, of course, testing and instrumentation are subjects on which a considerable contribution is made to individual industries by their respective research organizations, but there remains an extensive region for activity by the Association.

The original and continuing emphasis on optical work was illustrated during the open days by demonstrations of lens grinding and, judging from the interest displayed by visitors, many people were impressed by the speed and accuracy with which this can be accomplished to precise specifications by precision engineering set-ups. The Association has a small glass-making shop (a palette of colour glasses for artificial eye-making was displayed) and has made considerable contributions to the techniques of chemical analysis of optical glasses, as well as to the examination of such glasses by interferometry, polarimetry and microscopy, including the effects of ageing and attack by humid atmospheres, etc.

The utilization of modern synthetic resins in optical cements has evidently been developed with much satisfaction, and there were striking demonstrations of the preparation of polarizing films from suitable synthetics by molecular orientation, and of metallic mirrors, anti-reflexion films, interference filters for visible light, heat filters, etc., dependent on high-vacuum evaporation techniques.

The development of infra-red transparent materials has made a striking advance through the utilization of the fact (known for some time) that mixed crystals of thallium bromide and iodide are transparent to radiations in the region 0·5–40 μ. The process was demonstrated of growing single crystals in vertical cylindrical crucibles by a progressive freezing of the melt from bottom to top. The material, known as *KRS-5*, can be ground and polished and is chemically stable.

Graticule production may be described as one of the Association's 'specialities'. The methods adopted are mainly photographic in character and were well illustrated, together with the preparation of resolution test-slides for projection lenses.

Relatively recently, with the increasing use of electronic devices, the Association has built up a department well equipped to deal with a variety of electrical problems, exemplified by work on thermionic valves and valve amplifiers, electrometer valves, resistors of low temperature coefficient, magnetic amplifiers, the effects of dust on electrical contacts, etc. By contrast with the apparent complexities of

electronic work, there was also displayed in another room the success so far achieved in attempting to answer the simply stated question: How can one ensure free movement of mercury drops in sealed glass tubes such as are used in rocker contacts on electrical relays, etc., so as to avoid faulty make-and-break?

Studies on the gas permeability of thermocouple sheaths, performance specifications for electric ovens, fluid flow of liquids and gases, and the use of pneumatic (air-jet) gauges for observations on the curvature and thickness of lenses, provided further evidence of the wide scope of the Association's activities.

There were many indications of the flexibility of the broad divisional organization of the laboratories, supported by excellent drawing-office and workshop facilities. One learned that all divisions contribute to the information and liaison services, partly by providing background for the Information Department in dealing with technical inquiries, and partly by visits to member firms to study w ks procedures, to discuss immediate practical problems, and to seek advice about investigations being carried out by the Association. It is noteworthy that heads of divisions and senior staff generally are expected to spend some 20 per cent of their time in such visiting.

It would seem that those member firms which enter into active membership of the British Scientific Instrument Research Association in all its aspects may benefit exceedingly.

ALLEGHENY OBSERVATORY, UNIVERSITY OF PITTSBURG

A SHORT account of the origin and development of the Allegheny Observatory of the University of Pittsburg (pp. 12; from the University) has been compiled by Theodora M. Lauterbach, which makes very interesting reading. The appearance of Donati's Comet in 1859 aroused a new interest in astronomy, and a group of Pittsburg business men soon organized the 'Allegheny Telescope Association' and made plans for the purchase of a large telescope. This 13-in. refractor was made by Fitz, of New York, and was installed in the new building complete with dome, on a hill in the old city of Allegheny which later became part of Pittsburg. In 1867 the Association presented the telescope and building to the Western University of Pennsylvania—now the University of Pittsburg—and in the same year Samuel Pierpont Langley went to Pittsburg as professor of astronomy and director of Allegheny Observatory. Under him, and through financial assistance from William Thaw, a Pittsburg industrial leader, the equipment in the Observatory was greatly improved.

John A. Brashear, a former mill-worker, who had shown a wonderful aptitude for making lenses, and who was encouraged in this work by Langley, played a prominent part in the development of the Observatory. When James E. Keeler, who succeeded Langley in 1891, resigned in 1898 to take up the directorship of Lick Observatory, Brashear became temporary acting director until the following year, when F. L. O. Wadsworth took charge. During the latter's period as director, most of his time was devoted to supervising the construction of the buildings and instruments for the new Observatory, and with Brashear's assistance their efforts were rewarded by the laying of the foundation stone in October 1900. In 1912 the new Allegheny Observatory was dedicated and presented to the University of Pittsburg, and Dr. Frank Schlesinger was appointed director.

The account describes the excellent work of Schlesinger and the succeeding directors—Curtis, Jordan and others—and, as the author says at the end of this interesting brochure, "The Observatory's location serves well for uninterrupted research, and it is through research that Allegheny Observatory has helped to make the University of Pittsburg known throughout the world". The publication contains thirteen photographs of directors, instruments, and portions of the Observatory buildings.

NUFFIELD FOUNDATION

ANNUAL REPORT

THE seventh report of the Nuffield Foundation covers the year ending March 31, 1952*, and is the third in the current period of the present programme, during which allocations totalling £620,311 have been made for fundamental research in the United Kingdom; of this, £189,261 is for biological and £189,950 for sociological studies, and £110,000 is reserved for research overseas in the Commonwealth, of which £40,190 has been allocated in Australia, £12,712 in New Zealand and £18,500 in South Africa. The cost of existing schemes to the end of the quinquennium is estimated at the £498,892 already set aside, while £112,921 has been devoted during the current quinquennium to the continuance and extension of projects in medicine, science and the care of old people begun in the first programme. From the Oliver Bird Fund, £114,000 has been used or reserved for research in rheumatism.

By thus reserving in advance from current income £1,504,849 of £1,596,042 allocated in grants for the quinquennium, the Foundation seeks to assure itself of future freedom in the event of any fluctuations either in income or objectives and opportunities. For the advancement of research in the United Kingdom the Foundation has been concerned chiefly to stimulate studies in biology and sociology and, outside these two fields, any other research of real importance or promise which lacks the funds required for its full development. For financing projects of this latter type, the Foundation has set aside a sum which is termed the 'free fund', the use of which is essentially unplanned, and from this fund grants totalling £241,000 have been allocated during the past year. The greater part of this is to meet the Foundation's commitment to share with the Department of Scientific and Industrial Research the cost of the steerable radio telescope at the Jodrell Bank Experimental Station of the University of Manchester. This grant will avert the postponement of the project because sufficient public funds could not be made available. Grants from the same fund have been made to the University of Cambridge towards the cost of sinking and lining a borehole at or near the geophysical laboratories for experiments and measurements deep into the earth's crust, and towards the construction, during the next five years, of a new and improved high-speed electronic calculating

* Nuffield Foundation. Report for the Year ending 31 March 1952. Pp. 162. (London: Nuffield Foundation, 1952.)

machine. A three-year grant has also been made to Prof. J. Rotblat, of the Physics Department, St. Bartholomew's Hospital Medical College, to enable him to retain two technicians specially trained in the photographic emulsion technique he uses in his study of nuclear energy states, and a grant of £14,000 has been made to the Royal Anthropological Institute for the establishment for five years of the Nuffield blood-group research and reference centre, which came into operation on January 1, 1952.

Grants totalling £95,492 promised during the year for biological studies include those to the University of Cambridge for theoretical investigations at the Chemical Laboratory on molecular structure with the view of their application to biological problems and the study of animal behaviour, particularly studies of imprinting, habituation, insight and homing orientation at the Madingley ornithological field station; to the University of Leeds for studies on the molecular structure of collagen and infra-red techniques in the Department of Biomolecular Structure; and to the Lister Institute of Preventive Medicine to enable investigations on the isolation and characterization of antigens to be resumed and for the continuance of the work on co-enzyme A and related substances. Grants have been made to the University of London to increase the biological balance of the team working in the Wheatstone Physical Laboratory at King's College, under Prof. J. T. Randall, on the structure and function of nucleic acids in cells and the structure and fibrogenesis of the collagen of connective tissues; for the work on the embryonic brain at the Department of Anatomy and Embryology, at University College; and for the work on proliferation and morphology in the adult in the same Department, in association with the Department of Physiology; while grants have also been made to the Department of Clinical Pathology of University College Hospital Medical School for work on the red cells of human blood and to the Department of Morbid Anatomy for work on the responses to injury, and subsequent repair and regeneration, in liver and other tissues; the Obstetric Unit of the same School has received a grant for assisting the application of the sensitive electronic recording apparatus required for the further development of the work on the normal pattern of uterine contractions in child-birth and the effects of drugs on the contractions.

A grant of up to £4,000 has been made to the University of Manchester to enable Dr. H. C. B. Slack to investigate the metabolism of the extracellular substances of the body at the Rheumatism Research Centre. The University of Oxford has accepted grants for the continuance of work at the Physical Chemistry Laboratory on the mechanism by which resistance to various drugs and antibodies of a bacterial population is increased; for a graduate assistant to Dr. W. Holmes, of the Department of Zoology and Comparative Anatomy, to extend, along histological, histochemical and biochemical lines, his work on the adrenal cortex in lungfish; and for building up in the same Department a research unit in animal behaviour. A grant has also been made to enable the Strangeways Research Laboratory, Cambridge, to provide a worker trained in tissue culture and histology to collaborate with the Sir William Dunn Department of Biochemistry, University of Cambridge, in work on the effect of insulin and other hormones on the rudimentary long bones and animal tissues grown in tissue-culture.

The Foundation's grants for sociological studies are aimed primarily at aiding non-economic subjects, but two recent grants have been made for applied economic research: one of £6,500 to the Department of Applied Economics, University of Cambridge, is to collect and construct the social accounts of Cambridgeshire; the other, of £11,500, is to the Institute of Statistics, University of Oxford, for a national sample-survey of personal savings, to be carried out in two succeeding years. Both these projects have strong social implications and will make use of sample-interview techniques, thus contributing to the further development of this essential tool of social research. Grants totalling £3,200 have been made to the Department of Social Anthropology, University of Edinburgh, to finance work under Dr. Kenneth Little on the organization of Colonial students in London, their educational activities, etc., the social organization of coloured people in Manchester, and, in West Africa, on the complex social and economic factors which give rise to emigration and direct it to Britain. A grant has been made of £3,500 for the creation, for five years, of a research fellowship at Bedford College, University of London, to be held by Mrs. Barbara Wootton to review the whole field of social research. A grant of £4,000 has gone to the Department of Town Planning, University College, London, for a two-year study of the contribution of the social sciences to the principles and techniques of town and country planning and a survey of the processes of planning.

From the Oliver Bird Fund a further grant of £4,000 will enable the team under Prof. M. Stacey, in the Department of Chemistry, University of Birmingham, to continue for two or three years its studies of the organic chemical structure and enzymatic behaviour of the tissue components and joint fluids. The grant of £1,100 for the examination of the steroids of ox-bile, the original source of cortisone, under Prof. F. S. Spring at the School of Chemistry, Royal Technical College, Glasgow, has been renewed for a further two years. Renewed grants totalling £7,041, for the two years ending 1954, have been made to the Rheumatic Unit, Northern General Hospital, Edinburgh, for continued clinical work with cortisone, studies of cortisone as an adjuvant to the treatment of anæmia in rheumatoid arthritis and other fundamental work. Renewed grants have also been made to the Orthopædic and Accident Department, London Hospital, to enable Mr. A. Law to continue his studies of surgical treatment in rheumatic disease of the hip, spine and knee, to the Postgraduate Medical School, University of London, for the retrospective follow-up of patients, and to the South-west and Oxford Regional Research Unit, Bath, for completing therapeutic trials of X-ray therapy in osteoarthritis, rheumatoid arthritis, and spondylitis, and of intra-articular injections in osteoarthritis.

New grants for research overseas within the Commonwealth include those to the Waite Agricultural Research Institute, University of Adelaide, to enable Dr. H. L. Penman, of Rothamsted Experimental Station, to visit Australia in connexion with work on evaporation; for Dr. D. F. Thomson, of the Department of Anthropology, University of Melbourne, to visit social anthropologists in the United Kingdom and later to revisit Arnhem Land; to the Department of Chemistry, University of Western Australia, for equipment and infra-red spectroscopical research on Australian

natural products; to the University of Otago, for studies in the Department of Botany of morphology and chromosome numbers in *Ranunculus* and transplantation experiments and population analyses, at the Portobello Marine Biological Station, of the physiological mechanisms of animal behaviour and the interpretation of their structure in these terms, and, in the Department of Zoology, of the processes of bird-life. Grants have also been made to the University of Pretoria for work at the Plant Physiological Research Institute on nitrogen assimilation and metabolism in leguminous plants; to the Research Department of Ichthyology, Rhodes University, for research on freshwater fishes of southern Africa; to the Transvaal Museum, Pretoria, for completing the excavations at Swartkrans; and to the Bernard Price Institute of Geophysical Research, University of the Witwatersrand, for the establishment of a Nuffield Geochemical Unit.

For the second year's selection, applications for biological scholarships and bursaries have been stronger in number and quality, and out of thirty eligible applicants, two were awarded scholarships and one a bursary; two sociological scholarships and one bursary were also awarded to the twenty-two applicants under that scheme. The Foundation has reviewed the scheme of travelling scholarships for farmers of the United Kingdom, and reports from the National Farmers' Union suggest that the objects of the scheme are being achieved: ten awards, among sixty-four applicants, were made in 1951. Two travelling fellowships for Home Civil Servants, one in the administrative and one in the professional grade, were made in the year. Only six applications were made for dental fellowships, and three awards were made. Three medical fellowships were awarded among sixteen applicants.

Among new grants for miscellaneous projects may be mentioned one of £3,000 for the compilation of an archive of the Smuts papers and £15,000 towards the inter-congress meetings of the Association of Universities of the British Commonwealth; £650 to the British Committee for Flame Radiation Research to enable a British physicist to work at the Stockholm Technical College's water-cooled plant with heat-absorbing walls; to the British Sociological Association for its first three years, and to Dr. H. Lehmann, of the Department of Pathology, St. Bartholomew's Hospital, for investigations of the blood of south Indian aboriginal tribes, which seem to show that the sickle-cell trait connects the Veddians with Africa although their *Rhesus* blood-groups point to connexion with Australia. A grant of £1,580 to the University of Reading will enable Miss M. D. Vernon, of the Department of Psychology, to direct a three-year study of visual methods in teaching. New grants in continuation of past programmes include a final grant of £4,500 to the Joint Committee of the Royal College of Obstetricians and Gynæcologists, the Population Investigation Committee and the Institute of Child Health, for completing and publishing a report on the study of growth, health and environment of a sample of children from birth to the first year of school life; of £18,000 to the University of Cambridge for the work at the Psychological Laboratory on the problems of ageing, and of £600 for three years to Mr. F. Le Gros Clark for investigations on the social influences that determine retirement, and the employment of ageing persons, and on the capacity of industry to absorb the labour of ageing persons.

SEISMIC REFRACTION EXPERIMENTS IN THE PACIFIC

By Dr. T. F. GASKELL and J. C. SWALLOW
H.M.S. *Challenger*

THIS communication summarizes the results of seismic refraction experiments carried out in H.M.S. *Challenger* in the Pacific during the period October 1950–April 1952. Sixteen stations have been occupied in this area; their positions, and those of the Atlantic stations already described[1], are shown on the accompanying chart. The observed structures fit into five groups, described below.

(1) *Deep ocean types.* Four stations showed a sea bed consisting of a comparatively thin layer of sediment overlying material with a high velocity for compressional sound waves (20,500 ft./sec.). The velocity of sound in the sediment layer was not observed at these stations, but from other measurements is taken to be between 6,000 and 8,000 ft./sec. (Table *A*).

Reverse shots at stations 8, 10 and 11 showed that there was no appreciable slope under the hydrophones. There was no reverse shot at station 17, but the results from successive shots suggest that there may be a small slope, which would give a true velocity of 21,000 ft./sec., and a few hundred feet increase in sediment thickness.

(2) *Deep ocean near islands.* Two stations, one near the Hawaiian islands, the other twenty miles from Funafuti, showed a thin layer of sediment, followed by several thousand feet of material with a sound-velocity of 11,000–15,000 ft./sec. overlying the high-velocity layer (Table *B*).

At station 9, a reverse shot confirmed the 13,500 ft./sec. velocity, but at neither station were reverse points obtained from the high-velocity layer.

Allowing for the remaining possibility of a dip in this layer, the observed velocities are not incompatible with the previous value of 20,500 ft./sec. Adopting this velocity would change the thickness of covering material by only a few hundred feet.

(3) *Western Pacific.* Two stations in deep water, south-west of Formosa, showed a lower sound-velocity for the main layer, with about 2,000 ft. of sediment cover (Table *C*).

The depth of the sea bed was variable; but several reverse shots were made and corrections applied for dip under the hydrophones.

(4) *'Continental' types.* The results at stations 6 and 7, off the North American coast, were not checked by reverse shots, and were obtained over an irregular sea bed. However, two distinct layers are indicated at each station, and the velocity of sound in the deeper layer is substantially less than the 20,500 ft./sec. of the deep Pacific stations. Stations 14 and 15 show a velocity of about 17,000 ft./sec., confirmed by reverse shots (Table *D*).

At station 15, an increase of velocity with depth in the sediment layer was observed, from about 5,000 ft./sec. to 8,300 ft./sec., the latter layer probably being consolidated sediment.

(5) *Near deep trenches.* Stations 13 and 18 were in the deep trench south-west of Guam, at 11½ N., 142½ E. Some indication of a layer with very high velocity (27,000 ft./sec.) was obtained, but the results were rendered uncertain by drift of the hydrophones over a very irregular sea bed, and by the weakness of the ground waves obtained in these great depths

Table A

Station	Position	Depth (fm.)	Velocity in main layer (ft./sec.)	Sediment thickness (ft.)
8	35 N., 143 W.	2,880–2,940	20,900 ± 400	700–1,000
10	26 N., 164½ W.	2,560–2,610	20,300 ± 250	1,100–1,500
11	43½ N., 153 E.	2,770–2,860	20,800 ± 230	2,400–3,400
17	4 N., 146 E.	2,390–2,410	20,100 ± 400	2,100–2,900

Table C

Station	Position	Depth (fm.)	Velocity (ft./sec.)	Sediment thickness (ft.)
20	21 N., 127 E.	2,850–3,090	19,100 ± 1,400	1,500–2,100
21	20½ N., 124½ E.	3,030–3,170	18,800 ± 500	2,000–2,800

Table B

Station	Position	Depth (fm.)	Velocity in upper layer (ft./sec.)	Velocity in deep layer (ft./sec.)	Sediment thickness (ft.)	Cover material thickness (ft.)
9	22½ N., 160 W.	2,500–2,560	13,500 ± 200	23,000 ± 200	*c.* 100	9,300
16	9 S., 179 E.	2,660–2,690	11,000–15,000	22,200 ± 700	700–1,000	4,500–6,000

Table D

Station	Position	Depth (fm.)	Velocity in upper layer (ft./sec.)	Velocity in deep layer (ft./sec.)	Sediment thickness (ft.)	Upper layer thickness (ft.)
6	27½ N., 117 W.	1,830–2,290	10,800	17,200 ± 900	—	0–1,500
7	31 N., 117½ W.	970–1,120	> 9,000	19,400 ± 2,000	700–1,000	*c.* 5,000
14	8½ N., 143 E.	1,230–1,450	—	16,600 ± 260	1,700–2,300	—
15	18 S., 161½ E.	1,540–1,610	8,300	17,700 ± 300	1,100	7,900

Table E

Station	Position	Depth (fm.)	Velocity in upper layer (ft./sec.)	Velocity in deep layer (ft./sec.)	Sediment thickness (ft.)	Upper layer thickness (ft.)
12	14½ N., 141 E.	2,650–2,675	19,800 ± 1,100	28,000 ± 900	4,000–5,000	10,000
19	14½ N., 141 E.	2,630–2,680	20,000 ± 2,300	27,600 ± 800	1,200–1,600	10,000

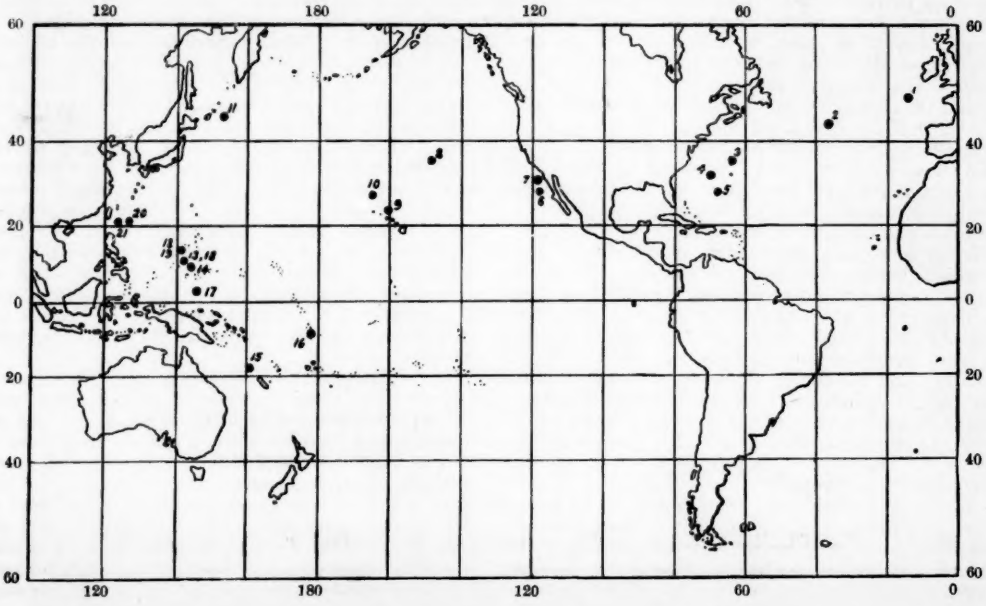
from the small explosive charges available. Station 12, and a repeat station in the same area (19), on the north side of the trench, were interesting in showing a very high velocity, comparatively near the surface (Table *B*).

At station 12, the very high velocity was not checked by a reverse shot, but is supported by the absence of any indication of dip along the direct line. The high velocity of station 19 is derived from shots between 12 and 16 miles from the hydrophones, in both directions.

The main part of the North Pacific basin may well consist of material showing a velocity of sound of 20,500 ft./sec. (probably gabbro or basalt) at least 8,000 ft. thick, covered by one or two thousand feet of sediment. Elevations of the ocean bed are characterized by a lower sound velocity, in the neighbourhood of 13,000 ft./sec., and such material was also observed in experiments on atolls (to be published separately). This probably corresponds to erupted volcanic rock, though it is possible for limestone to show such a velocity. There is evidence at both stations 9 and 16 that subsidence of the deep layer has occurred, due perhaps to the weight of volcanic material resting upon it.

An experiment in shallow water at Ominato in northern Japan showed material with a velocity of sound of 21,600 ft./sec. overlaid by about 6,000 ft. of sediment in which the velocity of sound was 6,400 ft./sec. The high velocity observed is in agreement with recent seismological observations in the same area, showing little, if any, thickness of granite.

The velocity of sound observed for the main layers at stations 20 and 21 is appreciably lower than that



found in the main Pacific basin, and may indicate the presence of a 'granitic layer' in this area, though 19,000 ft./sec. is a rather high velocity for granite. Its thickness would be at least 12,000 ft. assuming 25,000 ft./sec. for the next layer.

The very high velocity observed at stations 12 and 19 is similar to that assigned by seismologists to the layer below the Mohorovičić discontinuity. In the present case, this layer is only 11,000–15,000 ft. below the sea bed.

Station 15 was very similar to the Atlantic stations described by Hill and Swallow[2]. The increase of velocity with depth in the sediment observed at this station may have been present at others, though obscured by irregular topography and the greater depth of water. On the other hand, it may be a property of areas where large thicknesses of sediment have been laid down. The velocity of 17,700 ft./sec. obtained here is probably from a granite layer, and its thickness would be at least 7,500 ft.

These experiments could not have been made without the continuing assistance and co-operation of all on board H.M.S. *Challenger*, or without the support of the Hydrographer of the Navy, and of the Ministry of Supply. [June 19.

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CYTOCHEMICAL LOCALIZATION OF ESTERASES USING INDOXYL DERIVATIVES

By Dr. S. J. HOLT and R. F. J. WITHERS

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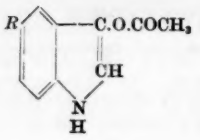
In response to many requests for further details of a new method for the localization of hydrolytic enzymes in tissues using indoxyl derivatives[1], it is felt that a further brief report is desirable before publication of a more extensive critical account. With derivatives of indoxyl itself, for example, (I, R = H), as enzyme substrates, a major drawback is that the indigo deposit formed by aerial oxidation of enzymically liberated indoxyl is granular or crystalline[1,2], with a particle size comparable to that of various cell structures. Accurate localization of enzymic activity is therefore difficult to determine, since one cannot readily distinguish between dye granules and dyed cell components, apart from other possible sources of error, such as diffusion of dye, chemical precursors of dye, or of enzyme. The factors controlling the size of the indigo crystals have been investigated and undesirable features eliminated as a result of systematic synthetic modifications of the indoxyl molecules as suggested earlier[1]. For this development, the chemically more accessible O-acetyl derivatives of indoxyl, having different substituents in the benzene moiety of the molecule, were studied. Like the parent compound (R = H), these were also found to be rapidly hydrolysed by the common carboxylic acid esterases.

Since the oxidative dye-producing reaction occurs after enzymic hydrolysis, the same indoxyl would be liberated from appropriate derived substrates by different enzymes[1]. The subsequent dye-forming reaction would therefore be the same for each enzyme.



(I)

The different indoxyl acetates thus served not only as simple models on which to study the general effects of chemical substitution on the nature of enzymically produced indigoid dyes, but also to investigate the localization of esterases in tissues. Of a large number of such compounds synthesized for this study[3], 5-bromoindoxyl acetate (I, R = Br) was found to be a satisfactory compromise between ease of preparation, tinctorial power and size of particles of the derived dye (5 : 5′-dibromoindigo). This rich blue, extremely insoluble dye was found to form a deposit so free from granularity that no particles could be detected in suitably homogeneous tissue sites (for example, contents of pancreatic duct) under the highest powers of the optical microscope plus photographic enlargement. In most other sites, granules, when produced, were far smaller than the common cell organelles (excluding microsomes). Only in the presence of gross lipoid (for example, fat cells) having esterase activity[4] did recognizable crystals appear, but even here these were much smaller than with the unsubstituted compound. Such sites could easily be distinguished, however, by carrying out control experiments with fat dyes such as Sudan IV.

The possibility of developing a method for the intracellular localization of esterases thus appeared to be possible, provided that the substrate penetrated to all cytological levels (see below), that the dye produced stained the cell organelles possessing esterase activity and that diffusion effects could be controlled. This was not immediately feasible, however, for several reasons. First, the indoxyl acetates failed to indicate, or only very inadequately so, the presence of esterases in certain sites of known high activity, for example, the motor end-plates of striated muscle. Here, a very diffuse staining reaction took place in both fresh and formalin-fixed frozen sections. This was traced to the rapid diffusion of the enzymically liberated indoxyl away from the site of generation into the surrounding tissue and substrate solution before complete oxidation to the corresponding indigo could take place. Such diffusion was intrinsically much less with the 5-bromo-derivative and with other similarly less soluble, high-molecular weight compounds. In all cases, diffusion was greatly reduced and localization improved by traces (10^{-4} M) of cupric salts, as mentioned previously[1]. This improvement has now been traced to the catalytic effect of the cupric ion in speeding up the oxidation of the enzymically liberated indoxyl.

The process thus seemed open to very much greater control than other histochemical localization procedures, by the use of oxidation catalysts or oxidizing reagents of graded strength, which obviously had to be selected to have as little effect on enzyme activity as possible. It appeared logical to assume that the more rapidly the free indoxyl could be oxidized to the corresponding indigo, the nearer the site of the enzyme would the dye be deposited. This hypothesis was fully borne out by experiment. Of the many oxidizing agents and catalysts tested for inclusion

in the substrate solution, potassium ferricyanide appeared to be the most satisfactory, agreeing with similar observations made during a parallel series of investigations by Burgen[5] at McGill University. A tendency for the indigo formed to be bleached by further oxidation to dehydroindigo could be prevented by also adding an equimolar proportion of potassium ferrocyanide. As test objects, in view of their fine and complex structure, the motor end-plates of mouse intercostal muscle and rat diaphragm were used. As the quantity of oxidizing agent was increased from zero to the optimum, the result produced in the muscle tissue, using 5-bromoindoxyl acetate as substrate, changed from the non-localized staining mentioned above, through diffuse circular patches on each muscle fibre, to a sharply delineated structure (Fig. 1) comparable with the results obtained by Couteaux[3] using his Janus green technique.

No further effect could be obtained by increasing the concentration of the oxidizing agent above 5×10^{-3} *M* of each component salt. With formalin-fixed tissues (see below) the motor end-plates already showed staining in as little as 10 sec. Even after 48 hr. incubation, the stained structures were merely very much darker than with the short period, which is a good indication of the specificity of the reaction, absence of autohydrolytic deposition of dye and negligible diffusion effects. With long incubation times, the only difference found was that the nerve supply to the end-plates became lightly stained.

Under optimum conditions, acetylindoxyl still produced a granular diffuse deposit, and we now consider that unsubstituted indoxyl is a poor basis for derived substrates for accurate histochemical localization of esterases.

Direct application of the optimum substrates to many other tissues produced, for the first time, consistent, easily reproducible intracellular localization of esterases. In particular, the results produced with rat kidney and liver were interesting. In the kidney, the sites of esterase activity in the tubular epithelium consisted of intracellular spherical bodies, diameter approximately 1–3 μ (Fig. 2), which, when stained less intensely than illustrated, often showed a concentric spherical structure, only the inner component being stained. In the liver, esterase activity was seen to be mainly associated with particles resembling liver mitochondria in appearance, clustered around the intercellular bile canaliculi (Fig. 3).

Results illustrated were obtained with tissues fixed for 16 hr. in cold (4°) neutral formalin (5 per cent formaldehyde) containing sodium chloride (0·9 per cent). Frozen sections were cut at a thickness of 5 μ and incubated in a substrate solution containing the following concentrations of components: 5-bromo-indoxyl acetate ($2{\cdot}5 \times 10^{-4}$ *M*), potassium ferricyanide and potassium ferrocyanide (5×10^{-3} *M* of each), calcium chloride (10^{-2} *M*), 0·1 *M* tris-hydroxymethylaminomethane maleate[7] buffer *p*H 8·0 (2 ml. in 10 ml. of substrate solution). Sections were examined periodically and removed when the stain, which appears spontaneously, was sufficiently intense.

Control experiments showed that none of the blue staining obtained in tissues was due to the presence of iron, which would give a Prussian blue deposit with the ferro-ferricyanide reagent. On the other hand, the use of steel needles to manipulate the tissues often resulted in contamination of this type, although it has not been observed after using steel microtome knives.

The use of fresh-frozen sections is unsatisfactory, for common reducing substances in such tissue quickly destroy the ferricyanide, apart from effects due to diffusion of enzyme.

With the degree of intracellular localization obtained, it soon became obvious that tissues fixed and cut as described above were inadequate for critical cytochemical studies. Apart from the well-known translocation of substances occurring during chemical fixation of fresh tissues[8], the relatively slow freezing at the microtome invariably produced some ice crystal artefacts. At present, frozen-dried tissues are being examined, as these appear to be more suitable for cytological studies[9]. Until results with frozen-dried material are fully evaluated, no claims are made for the accuracy of the cytological localization achieved with formalin-fixed material. The nature of the cell organelles staining by this process is also being studied by a number of complementary staining and optical techniques.

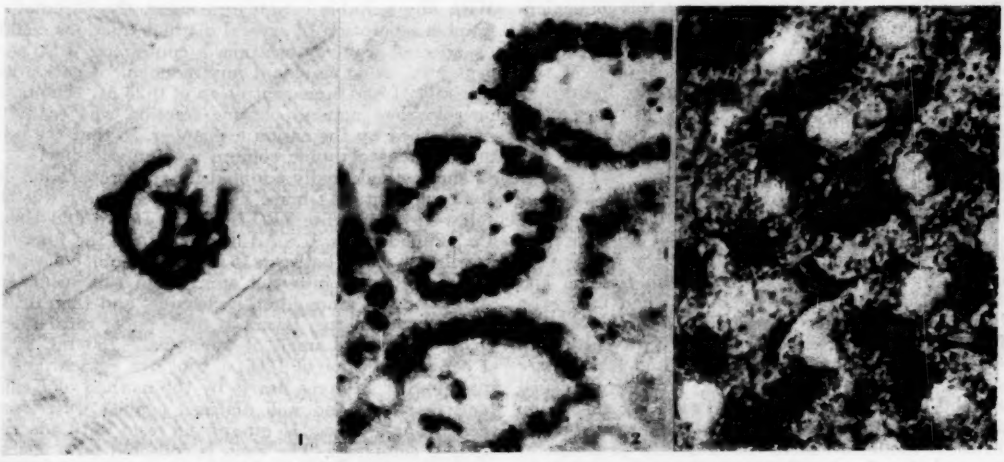


Fig. 1. Motor end-plate (mouse intercostal muscle); part was lost at upper right in cutting section. × 650
Fig. 2. Rat kidney. Esterase-positive spherical bodies in cells of tubular epithelium. × 850
Fig. 3. Rat liver. Esterase activity mainly associated with particles clustered around bile canaliculi. × 650

Non-critical methods for localization of enzymic activity usually show somewhat diffuse activity in tissues, particularly from the cytological point of view. Such methods may also indicate activity at sites known to contain no enzyme or vice versa. Observations of this kind have formed the basis for considerable doubts to be thrown upon the validity of histochemical staining techniques. In our experience, for precise localization, it seems essential that different types of tissue should be studied independently, to arrive at the optimum conditions for each. With the 5-bromoindoxyl acetate method described briefly above, good results are obtained with most tissues, except those of the central nervous system, where very little activity is demonstrable with the substrate solution described. This appears to be associated with the high phospholipin content of such tissues; but the difficulty can be overcome by modifying the ratio of the components of the substrate solution. We are studying this type of problem, but a full investigation of the use of 5-bromoindoxyl acetate with tissues of the central nervous system is being carried out by Burgen.

Apparently, different effects of the type mentioned above, in the action of tissues on enzyme-indicating substrates, are not by any means restricted to the indoxyl method. A typical case is that which arises with more familiar methods for the localization of esterases, such as the myristoylcholine method[10], the naphthyl acetate[11] and thiocholine[12] techniques. In each of these methods, in spite of claims to give good localization of esterase activity, none demonstrates such activity in one of the most important and least to be doubted sites of esterase, namely, the erythrocytes of, say, the rat. This does not even appear to have been specifically mentioned before, and should at once cast doubt on the validity of these methods, unless their scope and limitations have been previously thoroughly investigated, which does not appear to be the case. With the indoxyl method, in the absence of cupric ions or the ferro-ferricyanide mixture, the erythrocyte is one of the major staining sites. In the presence of the oxidizing catalyst or agent, however, the staining reaction is inhibited; this has been traced to the effect of these reagents on the special permeability properties of the erythrocyte membrane. The effect of copper in this connexion is well known[13]. In a subsequent publication it will be shown the failure to stain erythrocytes by the choline fatty acid ester technique is due to the failure of the quaternary ammonium salt substrate to penetrate the red cell envelope. In the naphthyl acetate method, the diazonium ions from the coupling reagent will also be shown not to penetrate the red cell membrane, and in the thiocholine techniques, sufficient copper is present in the substrate solution to destroy the permeability of this membrane. In addition, staining artefacts may well arise from a temporary or permanent fixation of the quaternary cations by acidic components of the tissue. The nuclear staining extensively found when using the thiocholine technique is probably due to such an effect and is being investigated. With substrates derived from indoxyl, chemically and electrically neutral molecules are involved, with which such artefacts should be minimal, and rates of penetration high, and possibly may become still higher as a result of further modifications of the molecular structure at present being developed.

We thank Mr. Peter Runnicles, of the Anatomy Department of this Medical School, for the photomicrographs, and the University of London for a grant to one of us (R. F. J. W.) from the Central Research Fund of the University. [November 6.

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PURIFICATION OF CYTOCHROME *C*

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THE first preparations of mammalian heart cytochrome *c* had an iron content of 0·34 per cent[1,2]. Theorell and Åkesson[3], however, showed that very prolonged electrophoresis in the large-scale Tiselius apparatus resulted in the separation of a fraction having 0·43 per cent iron. Less cumbersome techniques have been developed since for the production of the 0·43 per cent iron type of preparation[4,5], but they are not very reliable and have involved the use of conditions that cause a considerable reduction in the yield of cytochrome *c*. Paléus and Neilands[6] have used the synthetic polycarboxylic resin 'Amberlite *IRC*-50' for the chromatography of cytochrome *c* at *p*H 9, obtaining several fractions containing up to 0·466 per cent iron. The eluates obtained were very dilute and were concentrated by precipitation with trichloracetic acid in the cold. My experience has been, however, that this last step causes, in the absence of saturated ammonium sulphate, a very great reduction of the enzymic activity.

Preparation of 0·43 *per cent iron cytochrome c.* With any suitable cation exchanger, the chromatographic separation of several distinct fractions could be effected from cytochrome *c* containing 0·34 per cent iron, using as eluant any monovalent cation at neutral *p*H and a concentration of 0·25 *M*. The first or colourless non-cytochrome fraction was entirely unadsorbed by the cation exchanger, so that the use of a chromatographic column was unnecessary.

The method finally adopted for the preparation of 0·43 per cent iron horse heart cytochrome *c* was as follows: 'Amberlite *IRC*-50' (The Rohm and Haas Co., Philadelphia, U.S.A.) is ground and the fraction settling in water between 15 sec. and 3 min. collected. It is converted into the ammonium salt using an excess of 2 *N* ammonium hydroxide, and then dried in air between two layers of filter paper until there is no detectable smell of ammonia. 100 ml. of a 1 per cent solution of 0·34 per cent iron cytochrome *c*, prepared from horse hearts by the method of Keilin and Hartree[4], and well dialysed against water, are gently shaken with 15 gm. of the resin until adsorption is complete. The resin is collected on a coarse sintered glass funnel and thoroughly washed with glass-distilled water.

* On leave from the Hebrew University, Jerusalem.

The cytochrome *c* is then eluted with several washings of 15 ml. of 0·25 *M* ammonium hydroxide, keeping only the coloured portion of the eluate. The eluate is at once dialysed against running tap-water followed by three to four changes of distilled water, and finally filtered through a retentive filter paper.

The product has an iron content of 0·43 per cent, does not contain any denatured or modified cytochrome *c*, and with careful elution may be obtained in concentrations 1·5–2 times that of the original solution. It was found to be as fully active enzymically as the usual preparations, per mole of iron, in the succinic oxidase and cytochrome oxidase systems, these assays being carried out in Barcroft differential manometers at 37° C. and a *p*H of 7·3 (phosphate buffer), using varying amounts of added cytochrome *c* with cytochrome *c*-deficient enzyme preparations (kidney preparations, according to Slater[7], and heart muscle preparations, according to Tsou[8]) in the test systems given by Slater[7,9].

Repetition of the procedure three times on the same sample did not cause an increase of the iron content above 0·43 per cent. It is possible, however, that chromatography would give a higher iron content. The overall yield was 85–97 per cent.

The advantages of such a method over those previously used are its simplicity and rapidity, its reliability and the fact that the product is obtained directly in a concentrated form with full enzymic activity, the yield being practically quantitative. Moreover, the colourless fraction of the 0·34 per cent iron preparation is separated at its original concentration, giving an excellent starting material for its isolation and identification.

The success of this type of procedure depends on the fact that the isoelectric point of cytochrome *c* is at a *p*H of 10·6, thus making it act as a cation at lower *p*H values, whereas the associated protein substance or substances react as anions. Moreover, the cation exchangers effectively distinguish between native and modified cytochrome *c* in solution, only the native form being adsorbed; indeed, the products of the type of procedure described above show the same degree of reduction enzymically with succinic dehydrogenase as with an excess of sodium hydrosulphite, whereas the usual preparations commonly show a slightly greater degree of reduction chemically than when reduced enzymically.

The ease with which the colourless fraction of the 0·34 per cent iron preparations is separated by cation exchangers makes it reasonable to suppose that the bond between it and the rest of the molecule is a simple ionic one, confirming the electrophoretic observations of Theorell and Åkesson[3].

It should be noted that 'Amberlite *IRC*-50' is by no means the only cation exchanger which can be used, identical results having been obtained, for example, with 'Decalso *F*' (The Permutit Co., Ltd., London), which is an aluminium silicate.

Preparation of reduced or oxidized cytochrome c in a stable form. The simplicity of the procedure for adsorbing and eluting cytochrome *c* from a suitable cation exchanger makes it a very satisfactory method for the preparation of reduced or oxidized cytochrome *c*, free from any extraneous substance.

The techniques which have usually been employed are bubbling hydrogen gas in the presence of platinum black for reduction, which is effective only in rather dilute solution, or the use of chemical agents such as sodium hydrosulphite or ascorbic acid for reduction, and potassium ferricyanide for oxidation, leaving an excess of the reagent and its reaction products in solution.

The procedure using cation exchangers is as follows: 100 ml. of a solution containing 80–120 μmol. of 0·43 per cent iron horse heart cytochrome *c* prepared by the cation exchange method, is reduced with ascorbic acid or fully oxidized with potassium ferricyanide. Freshly prepared solutions are used, adding no more than twice the calculated stoichiometric amounts, the ascorbic acid being neutralized and containing versene (ethylene diamine tetra acetic acid) to stop its auto-oxidation.

The solution is then shaken with 20 gm. of the ammonium or potassium salt of 'Amberlite *IRC*-50, depending on the subsequent elution, per 100 μmol. of cytochrome *c*, until adsorption is complete; the resin is prepared as given above for the ammonium salt.

The cation exchanger carrying the reduced or oxidized cytochrome *c* is quickly collected on a coarse sintered glass funnel, thoroughly washed with glass-distilled water and sucked dry.

When oxidized cytochrome *c* is desired, the protein can be eluted as described above with 0·25 *M* ammonium hydroxide, filtered and immediately freeze-dried over sulphuric acid and sodium hydroxide.

When reduced cytochrome *c* is being prepared, it is necessary to avoid the alkaline *p*H's at which cytochrome *c* begins to be auto-oxidizable, and the elution is carried out with four to six washings of 20 ml. of 0·25 *M* potassium chloride. The eluate is dialysed for 5–6 hr. in the cold, with shaking, against running distilled water, filtered and freeze-dried.

The products are powdered and kept in ampoules sealed *in vacuo*. After storage at 0° C., the powders dissolve to give clear solutions having substantially the same percentage reduced or oxidized cytochrome *c* as when prepared, and showing full enzymic activity.

The advantages of this method over those hitherto used are the stability of the dried product in the reduced or oxidized form, the possibility of obtaining reduced or oxidized cytochrome *c* in a solution of any desired strength, and the complete freedom from the chemical agents used for reduction or oxidation and the reaction products. Such a product is particularly useful when it is necessary in enzymic studies to use cytochrome *c* in stoichiometric rather than catalytic quantities.

A detailed report of these techniques and their results will be published elsewhere. I wish to express my gratitude to Prof. D. Keilin for his constant advice and encouragement during this work. Thanks are also due to Dr. E. C. Slater for his advice in enzymatic matters, and to Mr. N. K. Boardman and Dr. S. M. Partridge for their help in the use of ion-exchangers. [Aug. 6.

Note added in proof. Neilands[10] now uses saturated ammonium acetate for elution from a column of 'Amberlite *IRC*-50', and obtains an enzymically active cytochrome *c*.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Resistance to the Potato Root Eelworm, *Heterodera rostochiensis* Wollenweber

I have already reported some of the results of my search for resistance to the potato root eelworm among the South American tuber-forming *Solanum* species in the Commonwealth Potato Collection[1,2]. This work, begun in 1941, is now practically complete, and more than 1,200 lines, belonging to more than sixty species, have been tested in duplicate on at least one occasion. Very few have been found to be resistant; one such line, *Solanum ballsii*, has certain disadvantages for breeding work as it is a diploid, whereas the domestic potato, *S. tuberosum*, is a tetraploid. In 1948, however, I was fortunate in finding a further five apparently resistant lines (C.P.S. numbers, 1673, 1685, 1692, 1595 and 1647), four of which belong to *S. tuberosum* sub-species *andigenum*, a group of tetraploids very close to the domestic potato and readily crossed with it; the other (1647) is a sterile triploid. Tests in later years have confirmed the early promise of these lines.

The routine tests to which all lines are subjected is of a very simple sort. The plants are grown in duplicate in pots of infested soil sunk in the soil of an infested allotment. At the end of the season, the plants are lifted and their roots examined for cysts. Promising lines are selected for further test if they have few cysts on their roots; but as this may be the case for a variety of reasons, factors such as the vigour of the plant and the extent and type of root system, etc., are also taken into account. Such an assessment, clearly, is of a subjective nature, and even though the evidence of repeat tests on a larger scale may reinforce a first impression, there is no evidence, as I have already pointed out[2,3], that the assessment is sound and the apparent resistance not the result, from the present point of view, of secondary factors. However, this possibility can be tested, for, by appropriate sexual and vegetative propagation, it is possible to compare a series of genetically different clones of common parentage and of very similar general habit; the results of such experiments are now available.

In 1951, Dr. K. S. Dodds, of the Potato Genetics Station, Cambridge, which houses the potato collection, supplied Dr. H. J. Toxopeus, of Wageningen, with selfed seed of three of the lines of *andigenum* first found by me in 1948 to be probably resistant. Some of his results are reported in the accompanying communication, and it is gratifying to find that they provide strong evidence that resistance to the potato root eelworm is probably inherited. The resistance of the four *andigenum* lines likely to be useful in potato breeding is now being examined on a much larger scale, both in Holland and in England.

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Sept. 29.

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Genotypical Background of Resistance to *Heterodera rostochiensis* in *Solanum tuberosum*, var. *andigenum*

In January 1951, we received from the Potato Genetics Station at Cambridge some selfed seed of three clones of *S. tuberosum* subspecies *andigenum* which, according to the experiments of Dr. C. Ellenby, seemed as if they might serve as a basis for breeding for resistance to potato root eelworm, *Heterodera rostochiensis*.

The seeds were sown immediately, and in April five to ten cuttings were made from each of the seedlings. These cuttings were transplanted into 7-in. pots filled with sandy soil heavily infested with potato root eelworm. The pots were embedded at random in the field and several rows of pots containing the domestic variety Eigenheimer were used as controls.

Six weeks after transplanting, yellow cysts could easily be seen on the roots of susceptible plants when they were removed from the pots. It appeared that all plants of a clone were either free or nearly free from cysts, or as heavily infected as the domestic controls. The results of the inspection are given in Table 1.

Table 1. Infection of *andigenum* Seedlings with Potato Root Eelworm

Parent	Number of clones	
	Without cysts	With many cysts
C.P.C. 1673	16	4
C.P.C. 1685	7	3
C.P.C. 1692	2	0

When the plants had finished growing, 20-c.c. samples of soil were taken from some of the pots and the number of cysts in each of these samples was determined. The results are given in Table 2.

Table 2. Counts of Cysts and Larvæ in 20-c.c. Samples of Soil

Material	Cysts	Viable cysts	Larvæ	Number of	
				Pots	Clones
S. tuberosum	58±6·5	47±5·4	4,300±635	10	–
S. andigenum susceptible	55±5·2	43±4·9	3,600±475	18	4
S. andigenum resistant	11±1·0	2	30	21	3
Initial potting soil	18±3·0	5±1	260±75		

It will be seen that twenty-five seedlings were apparently resistant to infection and that seven were susceptible. In the pots containing the domestic variety and the susceptible seedlings of *andigenum*, the number of viable cysts increased nearly ninefold, whereas, in the pots containing the resistant seedlings of *andigenum*, the population of cysts did not increase. These results suggest that resistance to potato root eelworm is inherited; but the progenies used were too small to permit an interpretation of the genetic mechanism involved.

S. tuberosum subspecies *andigenum* is cultivated in the Andean regions from Venezuela to northern Argentina, and apparently is closely related to domestic varieties, which represent only a small part of this very variable species. For this reason resistant *andigenum* varieties would seem to offer a very good basis for a practical breeding programme, and their possibilities are now being examined on a much wider scale.

H. J. Toxopeus
C. A. Huijsman

Institute of Agricultural Plant Breeding,
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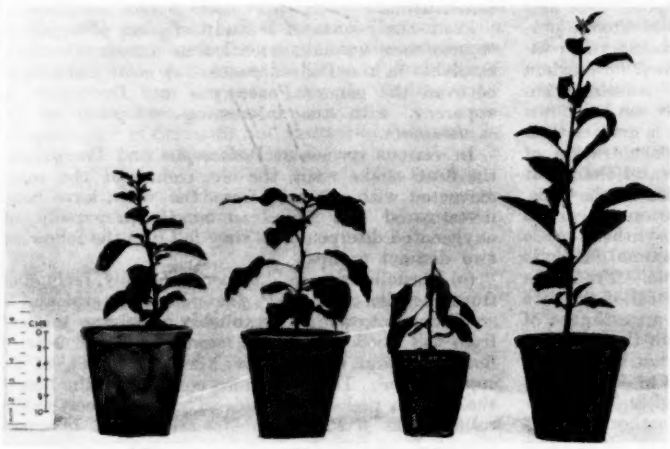
Wageningen. Sept. 29.

Pear–Apple Hybrids

At the John Innes Horticultural Institution we have recently raised hybrids between pears and apples; they were obtained in the following way. The occurrence of apomixis in the Pomoideæ[1], and the high frequency of diploid seedlings, 23 out of 39, in a family of pears we raised from crossing the diploid variety Fertility with the triploid variety Beurre Diel, suggested that they may have been apomictically, or in part apomictically, reproduced. To test this possibility one of us (E. M.) isolated a tree of Fertility, emasculated sixteen flowers and brushed the ovaries over with a 40 p.p.m. solution of β-naphthoxy-acetic acid. Four flowers were pollinated with the pollen of an unnamed tetraploid variety of apple and twelve with the pollen of the diploid apple Crawley Beauty. Twenty-four hours later the ovaries were again treated with β-naphthoxy-acetic acid. Three fruits developed from pollination with the tetraploid apple and twelve from pollination with the diploid. Seed content and germination are shown in the following table.



(*a*) (*b*) (*c*) (*d*)

(*a*) Pear; (*b*) surviving pear–apple hybrid; (*c*) dying pear–apple hybrid; (*d*) apple

Pear	Fertility 2*x*	Flowers	Fruit	Seeds	Seeds sown	Germinated	Survived
×	Apple 4*x*	4	3	13	13	13	1
×	Apple 2*x*	12	12	100	79	56	10

During the early stages of growth the seedlings were very uniform, and at first we thought they were pears of apomictic origin. Later their development was unusual, and it became clear that the plants were not pear seedlings but pear–apple hybrids. They developed intermediate characters, and after three months showed slightly greater resemblance to the male apple parent, though distinct from normal apple. Furthermore, all the seedlings had a somewhat defective root development and appeared to lack ability to take up sufficient of some of the essential mineral nutrients. In consequence, many of the seedlings died, but eleven have survived (see table and photograph). From preliminary grafting of some of the hybrids on to apple seedlings, it appears that difficulty in growth may be overcome.

One seedling in each family has been examined cytologically by Mr. R. D. Brock: the one in which the tetraploid apple was the male parent was triploid and the one with the diploid apple parent was diploid. This supports their hybridity.

In the past we have made pollinations between apples and pears but never obtained seeds. They were made without any hormone treatment, and it therefore seems that, when distant crosses with plants are being attempted, the use of β-naphthoxy-acetic acid may be of value.

It appears that this is the first time sexual hybrids between pears and apples have been produced. In *Plant Breeding Extracts*[2], an apple–pear hybrid is referred to in Sweden, at the Balsgård Fruit Breeding Institute; but Dr. I. Granhall, director of the Institute, has recently informed us that this is wrong and that no such hybrid is known in Sweden. According to Dr. Granhall, this false report originally appeared in a newspaper article. The alleged apple–pear vegetative hybrid Reinette–Bergamotte, referred to so much in recent years by Soviet scientific men, is figured, and an account of it given, in Michurin's "Selected Works". From the illustrations and the descriptive account of Reinette–Bergamotte, it appears to us to be entirely apple.

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Oct. 24.

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Rate of Photosynthesis and Concentration of Carbon Dioxide in *Chlorella*

Previous investigations of the relationship in *Chlorella* between rate of photosynthesis at high light intensities and concentration of carbon dioxide have been made using cells suspended in alkaline solutions[1]. In such solutions cells grown in 4 per cent carbon dioxide show an unusually long induction phase ($t_{1/2}$, 40–50 min.) at low concentrations of carbon dioxide; but when allowance is made for this and the rate of photosynthesis in the steady state alone considered, half the maximum rate is attained with a concentration of carbon dioxide[2] of $0{\cdot}9 \times 10^{-6}$ *M* at 25° C. The possibility has been suggested that in alkaline solution the relatively high concentration of bicarbonate ion affects the rate of photosynthesis[3].

Experiments have now been made with *Chlorella pyrenoidosa* in acid phosphate solution (*M*/30 potassium dihydrogen phosphate, *p*H 4·6). The cell suspension was placed in a tube containing a sintered glass bubbler which was connected in a closed circuit with appropriate drying tubes and with one absorption

tube of the infra-red gas analyser manufactured by Grubb Parsons. The control tube contained carbon dioxide-free air. Within the closed circuit a hermetically sealed pump continuously circulated the gas so that a complete cycle was achieved every 10–15 sec. The apparatus was calibrated by adding standard carbonate from a burette to acid contained in the bubbling tube, thus giving an absolute calibration as well as a measure of the response time of the system.

When *Chlorella* is placed in the bubbler tube and illuminated, the concentration of carbon dioxide progressively falls, and from the time-course the relationship between the rate of removal of carbon dioxide from the gas phase and the concentration in the gas phase can be determined. It can be shown that the actual rate of photosynthesis is greater than the measured rate, and that the concentration of carbon dioxide in the gas phase is greater than that in equilibrium with the aqueous phase in the cells. Thus any estimate of the concentration of carbon dioxide for half maximal rate of photosynthesis made from such observations must be maximal. Results are shown in the accompanying table. From the linear portion of a graph of the reciprocal of the rate against the reciprocal concentration, an estimate of the minimum concentration to give half the maximal extrapolated rate is $1{\cdot}20 \times 10^{-6}$ *M* (that is, allowing for solubility of the gas, $0{\cdot}95 \times 10^{-6}$ *M* in solution) at 25° C. This is in good agreement with our earlier measurements in alkaline solution; further, aliquots of cells from the same culture gave the same value using either method. Similar experiments with *Chlorella vulgaris* have been described by Egle (a report of which was not seen, however, until after the completion of this work), and his results are consistent with our own[4]. In the present measurements any possible role of bicarbonate ion is excluded since the concentration in solution at *p*H 4·6 is negligible.

Relationship between Rate of Photosynthesis and Concentration of Carbon Dioxide in *Chlorella pyrenoidosa*

Concentration of carbon dioxide (%)	0·0300	0·0108	0·0089	0·0070	0·0052	0·0033	0·0017	0·0013
Rate of real photosynthesis	18·0	16·8	16·3	14·6	12·9	11·5	8·5	6·8

The rate was determined after 40 min. illumination, that is, after the induction phase was ended. It is expressed as μl./μl. cells/hr. Concentration is in volume per cent at 760 mm. pressure. Temperature 25° C.; light intensity, 20,000 lux.: *p*H 4·6.

Both at *p*H 4·6 and 6·8 a long induction phase was observed at a concentration of carbon dioxide maintained between 0·01 and 0·02 per cent; but it was shorter the more acid the solution ($t_{\frac{1}{2}}$, 13 min. at *p*H 4·6; 18 min. at *p*H 6·8). At *p*H 6·8 and 8·2, preliminary experiments indicate that higher concentrations of carbon dioxide are necessary for half saturation.

A fuller discussion of these observations will appear in a joint paper with Prof. G. E. Briggs, to whom I am grateful for helpful advice. I also wish to thank the Agricultural Research Council for financial assistance.

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Chemical Differentiation of the Genera *Podocarpus* and *Dacrydium*

There are numerous instances where a genus or other group of plants is characterized by particular chemical constituents. In the Eucalypts, for example, chemical evidence has been of value in some instances in determining specific differences, while in *Pinus*, Erdtman and co-workers[1] have recently shown the presence of a characteristic pattern of heartwood constituents.

From the results of a study of rimu (*Dacrydium cupressinum*) we have been led to consider the data available in the Podocarpaceæ. A clear distinction between the genera *Podocarpus* and *Dacrydium* is apparent, with the interesting exception of *D. cupressinum*.

In various species of *Podocarpus* and *Dacrydium*, the heart-shake resin, the oleo-resin and the resin extracted with solvents from the wood have been investigated and found to consist principally of oxygenated diterpenoids. They fall into the following two distinct groups:

(*a*) Phenolic tricyclic diterpenes, namely, ferruginol from the oleo-resin of *P. ferrugineus*, totarol and a small amount of what is probably a hydroxy totarol[2] from the wood resin of *P. totara*, ferruginol 9-keto-ferruginol and totarol from the wood resin of *D. cupressinum*[3]. This wood also contains as the heart-shake resin podocarpic acid. The same heart-shake resin occurs in *P. dacrydioides* and in the Javanese species *P. cupressinus*.

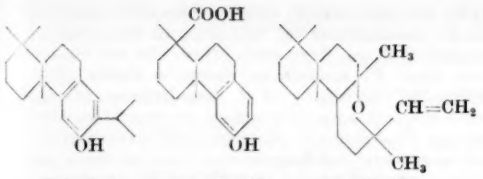
(*b*) Non-phenolic diterpenoids with two carbocyclic rings, namely, manool from *D. biforme*, *D. bidwillii*[4] and *D. kirkii*, manoyl oxide, 3-ketomanoyl oxide and a trihydroxyditerpene oxide from *D. colensoi*. These substances are all obtained by solvent extraction of the wood.

It should be pointed out that in *Podocarpus* the solvent-extractable resin has only been investigated in *P. totara* and *P. dacrydioides*[5]. The latter wood contains relatively little resin and the manool type of diterpenoid appears to be absent. *P. spicatus* gives a heart-shake resin containing the structurally unrelated matairesinol and conidendrin, but the solvent extract has not been studied. A summary of the diterpenoids of the resins of the *Podocarpus* and *Dacrydium* genera is set out in the accompanying table.

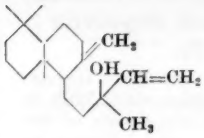
On the chemical evidence available, it appears that *D. cupressinum* shows much less affinity with

Constituents of the Woods of *Podocarpus* and *Dacrydium*

Wood	Constituents	Chemical type
Podocarpus ferrugineus	Ferruginol	Tricyclic phenolic diterpenes or related thereto
P. totara	Totarol, hydroxytotarol (?)	
P. dacrydioides	Podocarpic acid	
P. cupressinus	Podocarpic acid	
Dacrydium cupressinum	Podocarpic acid, totarol, ferruginol, and 9-keto-ferruginol	
D. biforme	Manool	Bicyclic oxygenated diterpenes (non-phenolic)
D. kirkii	Manool	
D. bidwillii	Manool	
D. colensoi	Manoyl oxide, 3-ketomanoyl oxide, a trihydroxy-diterpene oxide	



Ferruginol Podocarpic acid Manoyl oxide



Mnaool

Dacrydium, but a close relationship to, and should perhaps be placed with, *Podocarpus*. This conclusion is in agreement with the view that the anatomical features of the wood resemble those of *Podocarpus*[6].

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Early Effects of Growth Substances

ISOLATED cambium – phloem strips from *Bryophyllum calycinum* Salisb. show a curvature with the cambium at the concave surface, and this curvature is increased when the strips are placed in water. Plasmolysis causes the complete relaxation of the strip. Partial relaxation can be obtained in solutions of indolylacetic acid and 2,4-dichlorophenoxyacetic acid (2,4-D) in concentrations of 1–50 parts per million, the action of indolylacetic acid being in some cases reversible. It can be shown that the average width of the cambium cells decreases immediately after placing the strip in the hormone solution. The reaction is strongly influenced by temperature; it occurs between 15° and 30° C., with an optimum near 30° C. At 29° C. a maximal curvature of the strip (or shrinkage of the cambium cells) is obtained within five minutes. In indolylacetic acid, 1–20 p.p.m., a reversal of this shrinkage occurs which may lead to an increase beyond the original size of the cell; this might properly be considered as growth. At 29° C. the reversal appears twenty minutes after the beginning of the experiment.

Similar almost instantaneous effects of growth substances were demonstrated on the nyctinastic movements of various *Oxalis* spp., in which 2,4-dichlorophenoxyacetic acid, 1–100 p.p.m., and also indolylacetic acid cause a suppression, or even reversal, of the normal movement of the leaflets. This effect, too, may be accounted for by a sudden change of turgor, in this case in the pulvinar cells.

With *Bryophyllum* and carrot tissue, preliminary experiments have shown that 2,4-dichlorophenoxyacetic acid (1–50 p.p.m.) does not increase permeability to neutral red or ammonium ions. Plasmolysis in hypertonic glucose, as well as in glycerol, is materially accelerated in 2,4-dichlorophenoxyacetic acid, even in concentrations as low as one part in ten million.

We have also observed the disappearance of air from the intercellularies after treatment with 2,4-dichlorophenoxyacetic acid. This phenomenon, caused by an extrusion of water or cell sap, had been observed already in 1930 by Miss Nicolai[1] using cress roots mechanically stimulated at certain spots; at these spots the roots developed nodules. It is possible that the production of swellings by 2,4-dichlorophenoxyacetic acid, as well as the internal wilt which appears after its application, may yet be traced to the same cause, namely, an initial loss of water or sap from the cell.

The experimental work will be published in the near future. This research has been made possible by a grant from Timbrol Pty., Ltd., Australia.

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Corchsularin, a New Bitter Principle from Jute Seeds (*Corchorus capsularis*, Linn.)

SEN isolated corchorin[1], a crystalline bitter principle of melting point 174° C. and molecular composition $C_{23}H_{36}O_8$ and corchoritin[2], having melting point 218–222° C. and molecular formula $C_{12}H_{18}O_3$ from the alcoholic extract of jute seeds (*Corchorus capsularis*, Linn.). Karrer and Banerjee[3] obtained corchortoxin, having melting point 247° C. and molecular composition $C_{23}H_{32}O_6$. Soliman and Saleh[4] identified corchorin as strophanthidin.

We are also engaged upon a study of the bitter principles of jute seeds. Simply by extracting jute seeds with rectified spirit and digesting the alcohol-free extract with boiling water, a better yield of corchorin has been obtained. Corchorin extracted in this manner agrees largely as regards properties with those described by Sen and fails to show its identity with strophanthidin. It has also been found that a new bitter accompanies corchorin. This has been isolated and crystallized. It has a melting point of 157° C. and molecular composition $C_{30}H_{57}O_9$. Since this is neither corchorin, corchoritin nor corchortoxin, we propose a new name, 'corchsularin', for the substance. Corchsularin yields, on acid-hydrolysis, a new deoxy sugar, for which we also propose the name 'corchsularose'. Corchsularose has been found to be a deoxy methyl pentose.

A fuller account of this work will be published elsewhere.

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Identity of *Polystictus* (= *Polyporus* = *Trametes*) *cinnabarinus* (Jacq.) Fr. with *Polystictus sanguineus* (L.) Fr.

Externally, sporophores of the two species, *Polystictus cinnabarinus* and *P. sanguineus*, differ in the tint of red coloration and in the nature of the porous areas, though they are regarded by many as identical. Miss Wakefield holds (personal communication, 1948) *Polystictus sanguineus* as the tropical country-analogue of *Polystictus* (*Trametes*) *cinnabarinus* of the temperate climate. Cunningham[1], in his recent revision of Australian Polyporaceæ in herbaria of the Royal Botanic Gardens, Kew, and of the British Museum (Natural History), holds *Polyporus* (*Coriolus*) *sanguineus* Fr. to be identical with *Polyporus cinnabarinus* Fr., with the remark that "there is no constant feature upon which two species may be maintained". Cleland[2] is also of the same opinion, as he noticed fruit bodies of *Polystictus sanguineus* and *Polyporus cinnabarinus* growing in the same area of Sydney, almost at any time of the year after sufficient rain, on fallen logs. Lloyd[3] holds *Polystictus cinnabarinus* as the temperate region-analogue of the tropical *Polystictus sanguineus*.

Cultural characters of the two species in malt extract–agar slants, however, show important and constant differences between the two. The hyphæ of *P. sanguineus* usually soon develop red pigments[4] on their walls, and the whole slant looks mainly grenadine red, and scarlet red, scarlet or Brazil red afterwards[5], while the vegetative hyphæ of *P. cinnabarinus* remain perfectly uncoloured; only the porous areas, when eventually formed with development of basidia-initials, take on the characteristic Morocco red, scarlet, scarlet red, and Brazil red colour[5].

On pairing cultures of the two species on malt–agar-coated slides no hyphal fusion between the two could be observed; the hyphæ of the two colonies passed along each other without any fusion and there were abundant coilings (anti-clockwise under the microscope) of some hyphal branches of both, showing distinct inhibition as remarked by Brian *et al.*[6]. If there were thicker coatings of malt agar on slides, there appeared a distinct line of aversion between the two. Malt extract–agar plates were inoculated on the same day by the disk method with cultures of *P. sanguineus* and *P. cinnabarinus* on two sides of the plate at a distance of 3 cm. from each other. In the course of three days *P. sanguineus*, being a faster grower, surrounded the colony of *P. cinnabarinus*, leaving a visible distinct zone of aversion all round (see accompanying illustration). Microscopical examination of both aerial and submerged mycelium at the zone of aversion showed hyphæ of both species crossing each other with no hyphal fusion anywhere and with very pronounced anti-clockwise coiling of some hyphal branches of both.

From these characters it is concluded that the two species are distinct and are not identical, as held by previous workers.

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Enhancement of Streptococcal Bacteriophage Lysis by Hyaluronidase

It is well known that most Group A streptococci synthesize hyaluronic acid, which forms the streptococcal capsule, during the early stages of growth, and that mucoid colonies on blood agar are formed by strains that produce considerable amounts of hyaluronic acid. During attempts to propagate bacteriophages active against Group A streptococci, it was found that the organisms which survived and gave secondary growth were invariably mucoid. This observation suggested that the hyaluronic acid capsule might form a barrier between the organism and the bacteriophage and prevent attack. If this were so, then the inclusion of hyaluronidase in the medium might be expected to prevent the formation of a capsule and leave the organism vulnerable to attack by the bacteriophage.

Tests were made to find the smallest amount of purified hyaluronidase (Bengers) which prevented capsule formation in serum broth. In the subsequent tests with phages, five times this concentration was used.

Two phages, which ordinarily gave only partial clearing in broth, were added, together with their respective propagating strains, to plain serum broth containing hyaluronidase. The tubes were incubated for 15 hr. Those tubes containing hyaluronidase showed complete clearing; none of the others showed any evidence of lysis.

Dilutions of phage were then spotted on their respective propagating strains spread over the surface of glucose serum agar plates with and without hyaluronidase; in both cases the titre was higher on the hyaluronidase plates than on the controls (see table).

The effect of the hyaluronic acid capsule on phage action can also be illustrated by using mucoid and non-mucoid variants of one strain. On a 'glossy' non-mucoid variant of type 6, phage *A*6 had a titre

TITRATION OF PHAGE ON SOLID MEDIA WITH AND WITHOUT HYALURONIDASE

Strain	Serum glucose agar	Reciprocal of phage dilution				
		10	100	1,000	10,000	100,000
594	Control	CL	+	±	−	−
	„ + hyaluronidase	CL	CL	++	+	±
Type 12	Control	CL	±	−	−	−
	„ + hyaluronidase	CL	CL	CL	++	+

−, No plaques; ±, fewer than 10 plaques; +, 10–50 plaques; ++, 50 per cent lysis; CL, confluent lysis

of 1/1,000 with or without the addition of hyaluronidase. On a 'mat' mucoid variant of the same strain, the titre was only 1/10 without hyaluronidase; but using plates containing hyaluronidase the titre was approximately the same as on the non-mucoid strain.

Streptococci always appear more mucoid in media containing serum, and consequently the effect with hyaluronidase is more striking. Evans[1] has reported the inhibition of phage action by a variety of body fluids. The observations reported here suggest that this inhibition may be due in part to the promotion of capsule formation rather than to phage neutralization. Phage 594 used in this work is that used by Evans[2]. The other phages employed in these tests were given to us by Prof. N. A. Boulgakov, who isolated them from Paris sewage.

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[1] Evans, A. C., Public Health Reports, **48**, 411 (1933).
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An After-effect in Butter-fat irradiated with High-energy Electrons

IN a previous communication[1], a number of the oxidative effects produced in butter-fat by irradiation with high-energy electrons were reported as increasing with decrease of temperature during irradiation. Further examination has now shown that the changes which occur during irradiation are in some circumstances followed by extensive changes after irradiation, and that both are markedly affected by temperature. The main influence of temperature is, in fact, on the after-effect, which shows a surprising maximum reaction-rate in the region of − 20° C.

The effects during and after irradiation are clearly seen in the accompanying table. 1·2-MeV. electrons were used at a superficial dose-rate of 4×10^4 r.e.p./min. as described previously, and the butter-fat was a fresh sample saturated with air and water at + 37° C. Completely filled polythene dishes with sealed-on polythene-film lids were used to eliminate heating effects associated with the walls of glass vessels and the possibility of gross differences of oxygen content at different temperatures. Each line of the table is the average of duplicate experiments, in each of which a sample was irradiated at a given temperature and distributed in equal portions between a series of glass tubes pre-equilibrated to a range of storage temperatures. All manipulation, which was complete within two minutes of the end of irradiation, was in subdued artificial light and storage was in the dark.

EFFECT OF TEMPERATURE OF IRRADIATION AND STORAGE ON THE PEROXIDE VALUE OF BUTTER-FAT IRRADIATED WITH A DOSE OF 2 MILLION R.E.P. OF 1·2-MEV. ELECTRONS. (THE UNIRRADIATED BUTTER-FAT HAD NO MEASURABLE PEROXIDE VALUE)

Temp. during irradiation (° C.)	Temp. during storage (° C.)	Peroxide (μmol. oxygen/gm.) after storage for 0 days	2 days	8 days
− 70	− 70	3·0	4·2	4·5
	− 20		17·0	15·7
	0		5·1	7·3
	+ 20		4·3	5·1
0	− 70	3·0	3·0	5·0
	− 20		18·5	17·3
	0		7·1	7·4
	+ 20		3·1	6·0
+ 20	− 70	1·5	1·6	1·6
	− 20		1·5	1·6
	0		1·1	1·0
	+ 20		1·6	2·3
+ 37	− 70	0·2	0·6	0·6
	− 20		0·1	0·7
	0		0·1	0·6
	+ 20		0·8	1·2

It can be seen that fats irradiated at 0° C. or − 70° C. (on solid carbon dioxide) showed a striking increase in peroxide value[2] during the first two days of storage at − 20° C., compared with increases which were much smaller at 0° C. and barely significant at + 20° C. or − 70° C. Further investigations have shown that the reaction at − 20° C. follows a smooth reaction curve which in some cases does not attain its maximum value until four or five days after irradiation. Irradiation at higher temperatures gave a somewhat different picture. No after-effect was observed after irradiation at + 20° C., while the molten fat at + 37° C. failed to show even peroxide formation during irradiation. The same series of interrelationships was also given with an independent method of following the damage to the fat, namely, the Schibsted method[3], which is normally regarded as measuring aldehydes of high molecular weight. Since the butter-fat is molten above 35° C., semi-plastic at + 20° C. and virtually solid by about − 20° C., it appears possible that the changes are related to the physical state of the fat.

Some indication of the possible mechanism has been given by the demonstration that the typical reaction at − 20° C. occurred in samples which had been held for as long as 24 hr. at − 70° C. after irradiation, but not after three hours at + 20° C. Even 15 min. at + 20° C. (barely time for equilibration to temperature) eliminated three-quarters of the after-effect. These observations indicate the formation, by the radiation, of a reactive intermediary compound which is stable at very low temperatures and rapidly deactivated at room temperature or higher. At temperatures in the region of − 20° C. an intermediate state may exist in which the destructive mechanisms are suppressed, possibly by the decreased mobility, but the temperature is still sufficiently high for some localized reactions to occur.

A partial destruction of the small amounts of antioxidants (mainly tocopherols) present in the fat also occurs during and after irradiation. This can be demonstrated as a reduction of storage-life before typical rancidity develops, and has proved to be parallel to the peroxide value with all samples so far examined. In the present experiments, least destruction occurred with samples melted before, during or immediately after irradiation (storage life two to three days), while samples in which the peroxide had risen to high values at − 20° C. had no residual

storage life. It is not certain, however, that the antioxidant disappears at the same stage of the reaction at all temperatures, and further investigation is required before the part it plays in the whole series of changes can be suggested.

The relationship between these effects and those of normal autoxidation, or the after-effect observed spectroscopically by Mead[4] with X-irradiated linoleic acid, is still obscure. Qualitatively similar effects have also been shown with 40-kV. X-rays.

This work has been carried out with the co-operation of the Medical Research Council as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. We are grateful to Mr. J. W. Boag and Mr. D. Moore, of the Radiotherapeutic Research Unit of the Medical Research Council, Hammersmith Hospital, for carrying out the necessary irradiations.

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Differences in the Biological Activity of 2 : 3 : 5 : 6-Tetrachloronitrobenzene and its Isomers

In a recent paper[1], differences in the metabolism of 2 : 3 : 5 : 6-tetrachloronitrobenzene and the 2 : 3 : 4 : 5 compound in the rabbit have been described. Preliminary investigations in these laboratories have shown other differences between these compounds.

The 2 : 3 : 5 : 6 symmetrical isomer, formulated as a dust, has been used successfully to control *Botrytis* disease of lettuce[2] and dry rot of seed potatoes[3], and it has been shown to inhibit the sprouting of potatoes[4,5].

In our experiments, against normal strains of *Fusarium cæruleum* (Lib.) Sacc. in culture, 2 : 3 : 4 : 5 tetrachloronitrobenzene has inhibited radial growth more than the 2 : 3 : 5 : 6 isomer. Two of the mutant strains produced by McKee, and shown by him to be resistant to the 2 : 3 : 5 : 6 isomer[5], have been tested, and found to be less resistant to the 2 : 3 : 4 : 5 isomer. Both retained resistance to 2 : 3 : 5 : 6-tetrachloronitrobenzene after five months growth in its absence. In the accompanying table are results from an experiment in which subcultures were grown under the influence of the vapour from 0·01 gm. of the pure isomers deposited centrally in the lids of the Petri dishes.

Mean Increase of Colony Diameter (mm. per day): McKee Strain *B*

Strain	Tetrachloronitrobenzene isomers None	2 : 3 : 5 : 6	2 : 3 : 4 : 5
Normal	7·0	4·5	3·7
Mutant, resistant	5·3	5·1	3·7

When 1-lb. batches of Craig's Defiance potatoes were each dressed with 2 gm. of a 2 per cent dust of each isomer, and stored in closed tins until untreated controls were sprouting profusely, the following mean sprout weights were obtained :

Tetrachloronitrobenzene isomers None	2 : 3 : 5 : 6	2 : 3 : 4 : 5
26·8 gm.	16·4 gm.	27·9 gm.

With treated potatoes in small clamps, some inhibition of sprouting occurred with seed treated with the 2 : 3 : 4 : 5 isomer, but less than that in clamps treated with the 2 : 3 : 5 : 6 isomer. It is concluded that 2 : 3 : 4 : 5-tetrachloronitrobenzene is a less powerful inhibitor of potato sprouting than is the 2 : 3 : 5 : 6 isomer.

Application of the isomers as 5 per cent dusts to lettuce in boxes resulted in a visible check to growth, which was quickly overcome in the case of the 2 : 3 : 5 : 6 isomer but which persisted in plants treated with the 2 : 3 : 4 : 5 isomer and produced a significant reduction in dry weight of the final crop ($P = 0{\cdot}001$). It is concluded that both isomers can inhibit the growth of lettuce, but the 2 : 3 : 4 : 5 isomer is a more powerful inhibitor. Preliminary field-tests have shown the 2 : 3 : 4 : 5 isomer to be less effective than the 2 : 3 : 5 : 6 in controlling *Botrytis* disease of lettuce.

The limited examination yet made of 2 : 3 : 4 : 6-tetrachloronitrobenzene suggests it is more active than the other two isomers in inhibiting the growth of both *Fusarium cæruleum* and *Botrytis cinerea* in culture, and the sprouting of potatoes, but may be less inhibitory towards the growth of lettuce.

The investigations are continuing.

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Mode of Action of Agents giving Protection from Radiation

A considerable number of compounds is now known to be capable of protecting animals against X-rays and other radiations. Among the most effective of these are sodium cyanide and sodium azide[1], and thiourea[2]; alcohols[3] and amines[4] are active at higher concentrations. X-rays degrade polymethacrylic acid in aerated aqueous solutions, and the extent of the reaction could readily be followed by changes in viscosity with a high molecular weight sample of the polymer[5]. Table 1 shows that the degradation is reduced in the presence of substances which are protective agents in biological experiments. Since the compounds were placed in the same order of effectiveness in both tests, it is suggested that similar chemical reactions are involved. Allyl thiourea, which does not appear to have been examined biologically, was found in our work to be a highly effective protective agent.

Since polymethacrylic acid is not degraded by comparable doses of X-rays in the absence of air (see

Table 1. FALL IN VISCOSITY OF POLYMETHACRYLIC ACID (0·025 PER CENT NEUTRALIZED TO *p*H 7) ON IRRADIATION WITH 1,000 r. (200-KV. X-RAYS) IN THE PRESENCE OF COMPOUNDS GIVING PROTECTION AGAINST RADIATION

Protective agent	% fall in viscosity*
None	52
Solution saturated with nitrogen	2·0
4×10^{-4} *M* potassium cyanide	7·9
4×10^{-4} *M* allyl thiourea	0·0
8×10^{-4} *M* thiourea	14·0
8×10^{-4} *M* sodium azide	16·9
8×10^{-4} *M* methylamine	49
8×10^{-4} *M* methanol	40
250×10^{-4} *M* n ethanol	20

* Determined at a shear rate of 50 sec.$^{-1}$

Table 1) the primary products of the radiolysis of water, that is, hydrogen atoms and hydroxyl radicals, cannot be responsible for the breaking of carbon–carbon bonds in this system. The perhydroxyl radical, HO_2, is known to be formed by X-rays in the presence of oxygen and seems to be the most probable agent responsible for the degradation observed. Hydrogen peroxide, another product of irradiation, does not by itself react with the polymer even in high concentrations. These results indicate that the compounds examined here giving protection against radiation may react with perhydroxyl radicals possibly by adding an oxygen atom, for example, cyanide to cyanate, amine to amine oxide, sulphur compounds to sulphones or sulphoxides. The possibility that these compounds also react with hydroxyl radicals was tested in the following experiment.

Table 2. POLYMERIZATION OF AN AQUEOUS SOLUTION OF METHACRYLIC ACID (20 PER CENT) BY IRRADIATING WITH 10,000 r. (200-KV. X-RAYS)

Solution	% Monomer polymerized
Saturated with nitrogen	51·5
Saturated with nitrogen + 0·1 *M* thiourea	72·5
Saturated with nitrogen + 0·1 *M* allyl thiourea	51·0
Saturated with nitrogen + 0·1 *M* ferrous sulphate	20·0
Aerated	2·4
Aerated + 0·8 *M* thiourea	22·5

Hydroxyl radicals are catalysts in the polymerization of vinyl compounds, and in deoxygenated solutions methacrylic acid is readily polymerized by X-rays. Table 2 shows that this reaction is not inhibited by thiourea or allyl thiourea at a concentration sixty and one thousand times respectively of that needed to protect polymethacrylic acid against X-ray degradation; in fact, the polymerization in the presence of oxygen is promoted by thiourea. On the other hand, ferrous sulphate, which is well known to react with hydroxyl radicals, prevents the polymerization. Some at least of the compounds giving protection against radiation therefore do not react with hydroxyl radicals, whereas they all react with the radical responsible for the degradation. These experiments lead us to suggest that these substances protect against radiations *in vivo* by competitively removing perhydroxyl radicals formed in the presence of oxygen, and that it is the reaction of these radicals with vital cell constituents which brings about those of the biological effects (for example, radiation sickness) which can be counteracted by these chemicals. The protection afforded to animals by reduced oxygen tension[6] is in agreement with this hypothesis.

We wish to thank Prof. A. Haddow for his interest and encouragement, and Mr. C. A. Greatorex (Physics Department, Royal Cancer Hospital) for carrying out the X-ray irradiation. This investigation has been assisted by a special grant from the Anna Fuller Fund and by grants to the Royal Cancer Hospital and Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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The Stauromedusan *Craterolophus tethys* Clark in British Waters

THE stauromedusan genus *Craterolophus*, although bipolar, has appeared nevertheless to have a curiously restricted distribution[1]. The type species, *C. tethys* Clark 1863 [2], seems never to have been recognized outside the type locality Heligoland, though frequently reported in that region. The southern form, *C. macrocystis* von Lendenfeld[3], the specific status of which is in some doubt[1], occurs only on the New Zealand coast. Recent observations indicate that the northern form at least is more widespread than has been supposed.

Stauromedusæ make sporadic and infrequent appearances on the Yorkshire coast. *Haliclystus octoradiatus* and a supposed *Lucernaria campanulata* were first recorded from the Scarborough area in 1913 [4], but neither was seen again for nearly ten years[5,6]. Since the second appearance there have been no further records or reports of their occurrence; but in 1950 a chance find by Dr. W. S. Bullough at Robin Hood's Bay, Yorkshire, led to the discovery, after protracted search, of several specimens of what was thought to be a species of *Lucernaria*. This now proves after detailed examination to be, in fact, *C. tethys* Clark. The same species was again present, now in some numbers, in the summer of 1951, though in the intervening spring its absence was made the more conspicuous by the sudden appearance of *Haliclystus octoradiatus* (Lamarck).

It is quite certain that these appearances of *C. tethys* are not invasions by a species new to Britain, for by a fortunate chance a solitary specimen from one of the Scarborough collections mentioned above[4,5] is in the possession of this Department. Though allegedly *L. campanulata*, it is identical with the recent material. There is evidence, too, that the species has appeared in other localities. Johnston[7] described a *Lucernaria convolvulus* from Berwick Bay which is almost certainly not *L. campanulata* Lmx. to which he afterwards equated it[8], but on the other hand agrees more closely with *C. tethys*[2]. Johnston further considered that his specimens belonged to the

same species as others found on the Devon coast. This is of some interest, as a recent photograph of a specimen from this same region[9] seems more likely to be of *C. tethys* than of *L. campanulata*, to which it, too, is ascribed.

It seems very probable that *C. tethys* has appeared at intervals over a considerable stretch of the east and south coasts of Britain. It remains to be discovered whether it is established there, or whether it is a case of sterile distribution with periodical recruitment occurring from an outside source as a result of favourable circumstances at the time of reproduction. The latter alternative seems the less likely, since so far as is known the planula stage in the development of Stauromedusæ is of short duration, and therefore unlikely to be transported over any great distance.

I wish to thank Mr. P. G. Corbin both for the loan of specimens of *Lucernaria* and for much helpful discussion and assistance with the literature.

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Uricotelism in the Common Indian Apple-Snail, *Pila globosa* (Swainson)

Nitrogen catabolism in animals has been assessed partly by analysis of the excretory products and partly by the identification of the enzymes in the liver or hepatopancreas. Since Strohl reviewed the excretory mechanism in the Mollusca, work on a few European marine, freshwater and terrestrial gastropods has been extended[1-4]. Since no data are available for an amphibious snail and no parallel record for an Indian form, so far as we know, a study was undertaken on the common Indian apple-snail *Pila globosa* (Swainson). This particular form, besides being amphibious, develops through a cleidoic egg. The most active period of this snail's life is during the rainy season, when it lives in fresh water and feeds and also breeds on the banks. With the approach of the winter it becomes less active and burrows in the mud to æstivate for the rest of the year until the onset of the next rainy season.

During the course of the investigations, it was noticed that the uric acid content of the nephridium, which in this snail consists of an anterior and a posterior renal chamber, was rather low in the snails collected from their natural environment during the rainy season—being only 7·68 mgm. per gm. dry weight of the tissue in the anterior chamber and almost nil in the posterior renal chamber. After these snails have been maintained in the laboratory in wet jars in the shade for about a month, the quantity of uric acid increased to about 60 mgm. per gm. dry weight of the tissue in the anterior, and 14 mgm. in the posterior, renal chamber. When some of these snails were allowed to æstivate in the mud in the laboratory for a couple of months or more, the uric acid content of the nephridium gradually increased still further, as was shown by periodic estimations of the uric acid in their nephridia. It attained a maximum of about 102 mgm. per gm. dry weight of the tissue in the anterior, and 42 mgm. in the posterior, renal chamber, in the snails which had æstivated for more than six months.

A few of these æstivating animals with high uric acid content of the nephridium were selected and kept in water in small glass bowls, in which they were left for a number of days and periodically exposed to bright sunlight. They were examined one by one after regular intervals and the uric acid content of their nephridia determined. It was found that the quantity of the uric acid decreased with the length of time the snails were kept in the water (see accompanying table).

Period in water	Uric acid*		
	Anterior chamber	Posterior chamber	Total
Nil	102·38	42·58	144·95
15 days	78·3	50·88	109·18
21 days	79·04	10·23	89·27
27 days	29·88	Nil	29·88

* Uric acid content in mgm. per gm. dry weight of the tissue. Two or three snails were selected for each estimation.

Attempts were also made to see if this uricogenesis in *Pila globosa* could be correlated with certain enzymes present in the hepatopancreas and the nephridium of the snail. Following the technique of Baldwin[2] and Sumner and Somers[5] for arginase and xanthine oxidase respectively, it was possible to demonstrate the occurrence of both these enzymes in the hepatopancreas of *Pila globosa* in appreciable quantities. However, neither of these enzymes could be detected in the nephridium of *Pila globosa*. Whether these enzymes could be directly related to the æstivation of *Pila* is difficult to say[5,1], and so far it has not been possible to find any appreciable difference in the arginase content of the æstivating *Pila* and those living in an aquarium. The work is, however, being extended by one of us (B. B. S.).

All our experiments were carried out at room temperature with controls and blanks simultaneously.

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Ultra-Violet Papyrography: an Automatic Analytical Apparatus using Filter Paper without a Colour Reagent

A new analytical technique using filter paper and termed 'ultra-violet papyrography'[1] has been developed in these laboratories (Fig. 1).

The apparatus uses light from the ultra-violet (2537 A.) to visible region for the four methods:

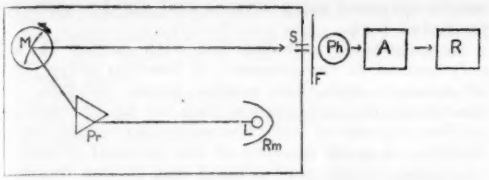

Fig. 1. *Rm*, Parabolic reflector for ultra-violet radiation; *L*, high-power mercury lamp; *Pr*, quartz prism for ultra-violet; *M*, concave reflector for ultra-violet; *S*, adjustable slit; *F*, filter paper; *Ph*, photomultiplier for ultra-violet; *A*, amplifier; *R*, recorder

(1) densitometry of finished filter papers prepared by paper chromatography or electromigration; (2) automatic paper chromatography; (3) automatic paper electromigration; (4) automatic paper electrochromatography.

Substances absorbing in the ultra-violet region may readily have their R_F values determined by use of ultra-violet light in method 1. In this case the finished filter paper is moved from the starting line to the solvent front. With methods 2, 3 and 4, a beam from a monochromator is projected on the fixed paper, and a sample is run by use of a developing solvent or an electric current. By these latter methods a quick automatic analysis of colourless substances is realized.

The apparatus can be used for both qualitative and quantitative analyses. By the methods of paper chromatography described, there have been obtained ultra-violet papyrograms for flavonoids[2], alcohol xanthates[3], and some organic bases[4]. Thus the accompanying papyrogram (Fig. 2) was obtained by ultra-violet densitometry (2537 A.) applied to the finished paper chromatogram of the hydrolysate of deoxyribonucleic acid.

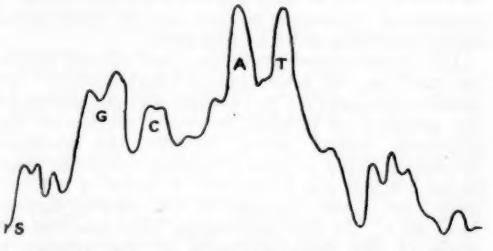

Fig. 2. *S*, Starting line; *G*, guanine; *C*, cytosine; *A*, adenine; *T*, thymine

This work was described at the annual meeting of the Pharmaceutical Society of Japan, at Osaka University, April 1, 1952, and a symposium of microchemistry of plant components held at Kyoto University, February 27, 1952. We are indebted to Prof. T. Kariyone, of Kyoto University, and Dean F. Seto, of this College, for guidance.

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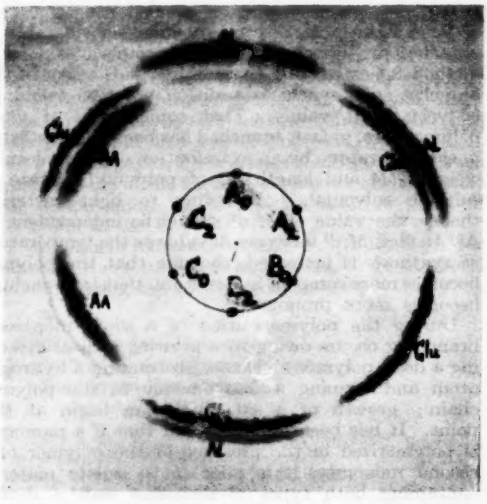
A Simple Paper Chromatographic Method for the Study of Transamination Reactions

RECENTLY, the application of paper chromatography to the study of transamination reactions has been reported by several workers. The method adopted by Fincham[1] is based on the visual comparison of the spots and as such it is only roughly quantitative. Tulpule and Patwardhan[2] reported a method based on conversion of α-ketoglutaric acid and pyruvic acid to the respective dinitrophenylhydrazones and estimating them colorimetrically after paper chromatographic separation. This method, even though claimed to be accurate, is obviously time-consuming and tedious. While our work on transaminating systems in Indian pulses was in progress, Awapara's paper[3] appeared in which the distribution of transaminases in rat organs was followed by using unidimensional paper chromatography.

In this communication is presented a simple method for the detection and quantitative determination of transaminase activity in plant tissues using the circular paper chromatographic technique[4–6], which is now being continuously used in this laboratory.

The following reactions have been studied by us: (*a*) alanine + α-ketoglutarate → glutamic acid + pyruvate; (*b*) glutamic acid + pyruvate → alanine + α-ketoglutarate; (*c*) aspartic acid + α-ketoglutarate → glutamic acid + oxalacetate.

The enzyme was prepared by extracting the powder of resting seeds (*Phaseolus radiatus*) with water (1 : 4, w/v) and dialysing the centrifuged extract against distilled water for 24–48 hr. at 0–5° C. The dialysed extract was centrifuged and the cloudy supernatant used in these experiments. The reaction mixture containing 0·1 c.c. of *M*/15 amino-acid, 0·1 c.c. of *M*/15 α-ketoglutaric or pyruvic acid (neutralized with sodium hydroxide), 1 c.c. of *M*/15 phosphate buffer (*p*H 7·4) and 0·8 c.c. of enzyme solution, was incubated at 35° C. for 2 hr. and the



Circular paper chromatogram showing presence of transaminating systems in green gram (*Phaseolus radiatus*). The reaction mixtures were spotted at positions marked on the circumference of the circle. A_2, B_2, C_2, refer to the reaction mixtures at 0 hr. for the systems mentioned in the text; A_3, B_3, C_3, to the same after 2 hr. incubation

reaction stopped by the addition of an equal volume of absolute ethanol. The protein precipitated was centrifuged off and 20 μl. of the clear supernatant were spotted on the paper and developed as described in earlier publications[5,6].

The accompanying photograph is of a typical chromatogram showing the presence of the above systems in green gram (*Phaseolus radiatus*).

The progress of the reaction was followed quantitatively by estimating the amino-acids by the following method[7]. The colour on the chromatogram was developed by spraying with 0·5 per cent ninhydrin in 95 per cent acetone, heating at 65° C. for 30 min., cutting off the individual amino-acid bands, extracting the colour with 4 c.c. of 75 per cent ethanol containing 0·2 mgm. of $CuSO_4,5H_2O$, and measuring the colour intensity with a Klett–Summerson photoelectric colorimeter using a green filter (540 mμ). An interesting feature is the effect of added cupric ions, which increases the tone and colour intensity considerably. The method is highly sensitive, simple and can be easily carried out in a short time.

Full details of this investigation will be published in the *Journal of the Indian Institute of Science*.

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Self-branching of Vinyl Polymers

The physical properties of a substance consisting of long-chain molecules are modified considerably if branches are introduced into the molecules, and a method for estimating the number and length of the branches in a synthetic addition polymer would be of very great value. That some types of vinyl polymers are, in fact, branched has been demonstrated in this laboratory by an examination of the molecular weight (M) and length (d) of polyvinyl acetate in suitable solvents[1]. According to light-scattering theory, the value of M/d^2 should be independent of M. In fact, M/d^2 increases in value as the temperature of synthesis is increased, showing that the polymer becomes more compact in structure, that is, branching becomes more pronounced.

During the polymerization of a vinyl monomer, branching occurs owing to a growing radical attacking a dead polymer molecule, abstracting a hydrogen atom and forming a free valency in the polymer chain; growth of a side-chain can begin at this point. It has been demonstrated that if a monomer is polymerized in the presence of the polymer of a second monomer, it is possible to isolate material containing both types of monomer unit[2]; during the polymerization, side-chains must have been grafted on the dead polymer. A new method has now been developed for studying the branching reaction using a single monomer, and preliminary results obtained using styrene and vinyl acetate are presented here.

Monomeric styrene labelled with carbon-14 was polymerized in the presence of inactive polystyrene of average molecular weight about 500,000, the conditions being adjusted so that the active monomer yielded polymer of fairly low molecular weight (about 50,000). A small fraction of the material of highest molecular weight was isolated and it was found to possess an appreciable amount of activity. In order to calculate the amount of activity which was chemically combined with the high polymer, it was necessary to perform a blank experiment and to make allowance for incomplete separation of active low polymer and inactive high polymer.

Comparison of the activity grafted on the high polymer with the activity of polymer formed directly from the active monomer would have permitted calculation of the number of branches in the system if the average length of the branches had been known. It was assumed that the average length of the branches was equal to half the average chain-length of the linear polymer formed at the same time. The rate of formation of branch-points, which is equal to the rate of transfer to polymer, is $k_x n(M.U.)$, where n is the number of growing centres in the system and $(M.U.)$ is the concentration of monomer units incorporated in the polymer. The value of n can be calculated from the observed rate of polymerization, the concentration of monomer and the velocity constant for chain-growth. Provisional values in litre mole^{-1} sec.$^{-1}$ for the constant k_x are 0·35 at 130° C. and 0·56 at 154° C., giving approximately 7 kcal. as the energy of activation. At 154° there is one branch of 115 monomer units for about 7,920 monomer units in the linear polymer. If the polymerization of styrene is carried to high conversion at elevated temperatures, an appreciable number of branches may be formed; but at temperatures below about 100° C. in reactions allowed to proceed only to small conversions, branching must be negligible.

The experimental procedure was altered slightly for studying the branching of vinyl acetate. Unlabelled monomeric vinyl acetate was polymerized in the presence of labelled polyvinyl acetate of high molecular weight (about 660,000), the conditions being such that a polymer of average molecular weight about 100,000 was produced. A value of 8·1 litres mole^{-1} sec.$^{-1}$ was obtained for the velocity constant k_x at 40° C. At this temperature there was one side-chain of 582 monomer units on the average for 2,760 monomer units combined in the form of linear polymer. Clearly, transfer to polymer and branching are of more significance in the polymerization of vinyl acetate than in that of styrene, owing to the much higher reactivity of the vinyl acetate radical.

The results indicate that the value of the velocity constant k_x is similar to those for the velocity constants for transfer to monomer (k_f) and for transfer to small molecules (k_f'), which can be taken as models for the monomer unit in the polymer[3]. For styrene at 130°, k_x was found to be 0·35 litre mole^{-1} sec.$^{-1}$, while k_f and k_f' for ethyl benzene are calculated as 0·34 and 0·45 litre mole^{-1} sec.$^{-1}$ respectively. In the case of vinyl acetate, k_x at 40° is 8·1 litres mole^{-1} sec.$^{-1}$, while a value of about 5 litres mole^{-1} sec.$^{-1}$ has been quoted for k_f at 50° C.

It can be predicted that branching is most likely to be important for monomers which yield reactive radicals, for example, vinyl chloride; branching

might be particularly pronounced with this monomer, as the abstraction of a chlorine atom by a free radical should occur more easily than the abstraction of a hydrogen atom.

The results of experiments with further monomers, and full details of the experimental procedure, will be published elsewhere.

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Oct. 16.

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Anomalous Specific Heat of Chromium Oxide (Cr_2O_3) at the Antiferromagnetic Curie Temperature

Recently, some observations have been published of phenomena related to the second-order transition of chromium oxide (Cr_2O_3) at the antiferromagnetic Curie temperature; for example, the change of lattice constants[1] and the anomalous absorption of high-frequency electromagnetic energy[2]. However, so far as I am aware, no measurements of an anomalous specific heat have been published. In the present communication, measurements are presented of C_p between 100° and 350° K. and of the magnetic susceptibility χ between 77° and 550° K., which were made on samples of the same preparation of chromium oxide.

The compound was prepared by firing ammonium dichromate in air at 1,000° C. The susceptibility was measured on a sample of 280 mgm. of the resulting oxide by the Faraday method (force on the specimen in an inhomogeneous magnetic field). The torsion spring balance used was an improved design of that described elsewhere[3]. The results are plotted in Fig. 1. It is remarkable that the values of χ at low temperatures are lower than those found by Foëx and Graff[4], whereas the high-temperature values of χ seem to be somewhat higher than was found by these investigators. The dip of the curve which is believed to indicate the antiferromagnetic Curie temperature is found at 45° C.

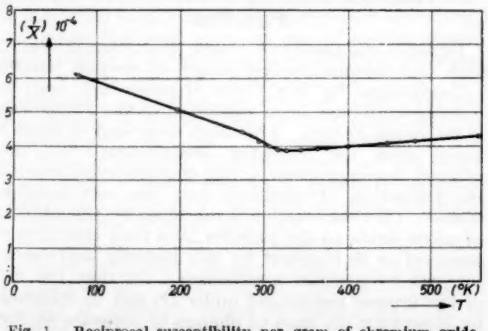

Fig. 1. Reciprocal susceptibility per gram of chromium oxide as a function of temperature

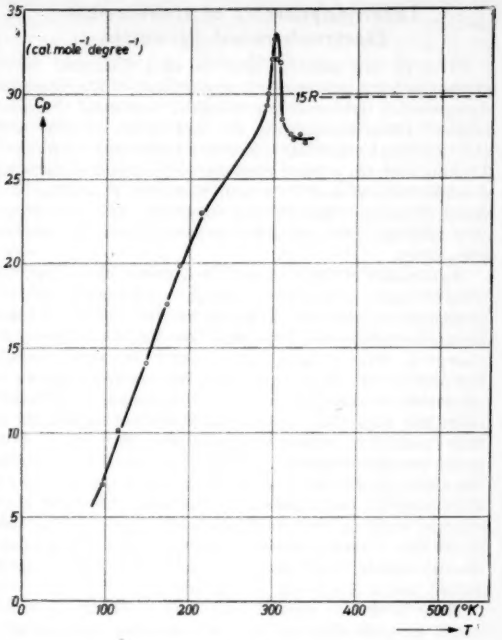

Fig. 2. Molecular specific heat of chromium oxide as a function of temperature

The specific heat was investigated on a sample of 29·6 gm. The substance was well enough sintered to form one solid piece, so that no container had to be used for the calorific measurements. The apparatus and method were the same as described by Volger[5]. The results are given in Fig. 2. Obviously, the anomaly of C_p at about 35° C. is due to the final disappearance of the antiferromagnetic ordering. The very steep drop of C_p was confirmed by the continuous heating method (analysis of the drift of temperature caused by a very small supply of heat[5]). Similar anomalies of the specific heat have been observed with oxides of other transition elements exhibiting antiferromagnetism; for example, manganese oxide (MnO) and dioxide (MnO_2), and iron oxide (FeO) and also with copper oxide (CuO)[6,7].

In a recent paper, Foëx[8] states that his unpublished measurements of the thermal expansion or the specific heat of chromium oxide indicate a Curie point of this oxide at 40° C.

I am much indebted to Mr. F. C. Romeyn for preparing the compound, and to Mr. J. H. Aalberts for help during the measurements.

J. Volger

Philips Research Laboratories,
N.V. Philips' Gloeilampenfabrieken,
Eindhoven, Netherlands.
April 24.

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[2] Trounson, E. P., *et al.*, *Phys. Rev.*, **79**, 542 (1950).
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[4] Foëx, G., and Graff, M., *C.R. Acad. Sci., Paris*, **209**, 160 (1939).
[5] Volger, J., *Philips Res. Rep.*, **7**, 21 (1952).
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[7] Miller, *J. Amer. Chem. Soc.*, **51**, 215 (1929).
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Thermodynamics of Irreversible Electrochemical Processes

In a recent paper, DeGroot and Tolhoek[1] have attempted, by means of an application of the thermodynamics of irreversible processes, to extend Guggenheim's[2] ideas concerning the activities of ions and the electrical potential difference between two phases. To this end they have considered a medium showing a bulk motion and in which chemical reactions and flows of energy, matter and electricity are occurring; two different mathematical treatments of this system are given.

As a result of their second treatment, these authors deduce that electrical potential differences are (in principle) measurable apart from differences in ionic chemical potentials, provided that an electrical space charge is present, that is, in nearly insulating media but not in media showing any appreciable degree of electrical conductivity. This conclusion is obtained from the fact that the thermodynamic equations of this method of treatment, provided that there is no space charge, contain the chemical potential μ_i of the ith ionic species and the electrical term $e_i\varphi$ (where φ is the electrical potential of the medium and e_i the ionic charge) only in the combination $\bar{\mu}_i = \mu_i + e_i\varphi$, that is, as the electrochemical potential of i; if a space charge exists, however, the equations contain additional terms involving φ but not μ_i.

Now both the second and first methods of treatment involve the use of the following thermostatic equation for the change in intrinsic energy of a system:

$$\mathrm{d}U = T\mathrm{d}S - p\mathrm{d}V + \sum_i \mu_i \mathrm{d}n_i, \qquad (1)$$

where the symbols have their usual thermodynamic meaning. Since the change in U is quite independent of the path followed, it is quite correct to apply this equation to any process whatever occurring in the system, reversible or irreversible. However, it is subject to the restriction that the system does no specialized work, that is, no work which cannot be included in the second and third terms on the right of (1). It is therefore quite erroneous to apply it to a system containing electrical charges and potentials, which can perform electrical work.

It is readily ascertained from thermostatic first principles that, when a system can perform specialized work, a term representing the maximum specialized work that it is capable of performing under reversible conditions must be added to (1). The equation is then still applicable to an irreversible change, for the same reason as before; but it must be noted that the specialized work term is then not equal to the specialized work which has actually been performed in the process. In the case of electrical work, the correct form of the equation is obtained by replacing the chemical potentials μ_i in (1) by the electrochemical potentials $\bar{\mu}_i$ as defined above:

$$\mathrm{d}U = T\mathrm{d}S - p\mathrm{d}V + \sum_i \bar{\mu}_i \mathrm{d}n_i. \qquad (2)$$

It is this expression, not (1), which must be taken as the basis of the thermodynamic treatment of an irreversible electrochemical process, although the erroneous use of (1) has apparently been in vogue for a number of years[3].

If now the first method of DeGroot and Tolhoek is carried through using (2) in place of (1) as the only modification, it will be found that the equations finally obtained do indeed contain μ_i and φ only in the combination $\bar{\mu}_i$; in particular, the thermodynamic force acting on the ith ion is given by:

$$X_i = F_i - T\,\mathrm{grad}(\bar{\mu}_i/T), \qquad (3)$$

where F_i is the non-electrical external force acting on the ion (the effect of external electrical forces is already included in the φ term of $\bar{\mu}_i$). Equation (3) leads to the usual and well-known results when applied in any particular problem. Thus from this first treatment alone it is seen that no thermodynamic measurement can ever determine separately either the electrical or non-electrical part of $\bar{\mu}_i$, no matter whether or not a space charge exists in the system.

The second method of DeGroot and Tolhoek can also be carried through with the same modification, but then some rather peculiar equations result. In this method, instead of the intrinsic energy U, used in the first case, a quantity $\bar{U}$ is employed; this is said to be the "intrinsic energy, including electrical energy", and is defined as:

$$\bar{U} = U + e\varphi, \qquad (4)$$

where e is the total electric charge in the system. However, the intrinsic energy U does, by definition, include the totality of the energy contained in the system, so the addition of the term $e\varphi$ is tantamount to including the electrical energy twice over. Thus $\bar{U}$ as defined by (4) is a new thermodynamic function which might conceivably have some particular applications, but which certainly cannot be used in place of U in equations (1) and (2).

The whole of this second method of treatment must therefore be considered invalid. This leaves us with the conclusion, drawn from the revised first treatment, that thermodynamic measurements on any system will never give us anything other than the electrochemical potentials $\bar{\mu}_i$ of the ionic species concerned. This is in complete agreement with Guggenheim's original conclusions. The question of whether or not the electrical and non-electrical parts into which the $\bar{\mu}_i$ may be formally split have any real physical significance is, however, quite another matter and cannot be discussed here.

Peter H. Kemp

43 Athenæum Road,
London, N.20. Aug. 19.

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[2] Guggenheim, E. A., *J. Phys. Chem.*, **33**, 842 (1929); **34**, 1540 (1930).
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Thermal Decomposition of Normal Paraffins

During the past two years, four papers dealing with the thermal decomposition of normal paraffin hydrocarbons by Sir Cyril Hinshelwood and his collaborators have been published in the *Proceedings of the Royal Society*. The work described in them is based upon the following assumptions: (1) that primary decomposition, in the simplest case, involves the formation of methane, and the corresponding olefine; (2) that reaction is inhibited by the addition of nitric oxide to the paraffin, and may therefore be assumed to be initiated by free radicals, and carried forward by a chain mechanism; (3) that the rate of the process mentioned under (1) can be measured by observing the rate of change of pressure at constant volume and temperature.

Before the War, one of us with various collaborators had shown that, in the case of ethane: (1) primary thermal decomposition of the hydrocarbon results in hydrogen and ethylene only; this process is inhibited by the addition of nitric oxide to the ethane; (2) the formation of methane, and under certain conditions of methane and polymer together, is secondary to the formation of hydrogen and ethylene. The formation of methane, or of methane and polymer together, which is a measure of the rate of disappearance of C_2-hydrocarbon, is the result of a single time-determining process, the rate of which is not diminished but slightly accelerated by the presence of nitric oxide.

The behaviour of ethane might be supposed to be unique, and we assume that for this reason this work has not been referred to in the papers we have mentioned. We have now proved, however, that the thermal decomposition of propane follows exactly the same course. This fact, and others of which we give details in a paper which has been communicated to the Royal Society, appear to us to justify the claim that the manner in which normal paraffin hydrocarbons decompose when heated is that which we have described. The locus of the rupture of the carbon chain is that of the ethylene bond in the product of the primary olefine. In the case of ethane and propane there can, of course, be only one olefine. In the case of butane one would expect that the primary olefine would be 1-butylene, from which the secondary products would be methane, possibly with some polymer, and propylene. But in the region of our experiments a shift in the position of the double bond would give rise, in the first instance to some dimethyl–ethylene, the secondary products from which would be ethane and ethylene. This is what is actually observed.

We believe that the results which we have obtained places our knowledge of this very important set of reactions on a firm experimental foundation.

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Gloucester Technical College.
MORRIS W. TRAVERS
University, Bristol.
Sept. 29.

IT is not correct to say that the work from this laboratory referred to is based upon the 'assumptions' (1), (2) and (3) of the communication from Mr. C. G. Silcocks and Prof. M. W. Travers. That the reactions are partly chain reactions, and that in many cases pressure change is quantitatively proportional to decrease in amount of original paraffin, represent considered conclusions from detailed experiment. (1) has never been stated: the formation of methane and olefine has been given as one of several simultaneous modes of decomposition of the higher paraffins.

The writers appear to think that the primary and predominant formation of ethylene and hydrogen from ethane is incompatible with a chain reaction involving alkyl radicals. Reference to almost any text-book on chemical kinetics shows that this would be an error. (According to a generally accepted scheme—not devised by us—the ethylene is formed by breakdown of ethyl radicals.)

The implication of (3), that work in this laboratory has uncritically used change of pressure as a measure of reaction-rate, is wholly unfounded. Detailed analyses at different stages of various reactions of paraffins have been made repeatedly, and indirect tests that the kinetic conclusions are independent of possible errors from this source have also been applied. One of the latest published sets of analyses is in *Proc. Roy. Soc.*, A, 214, 20 (1952), and here it is again specifically shown that change of pressure gives a good measure of initial rate. The results also contradict decisively Prof. Travers's contention that the higher paraffins would give primarily olefine and hydrogen only. With normal butane at 530° C. and 1,400 mm. initial pressure, when the increase of pressure is 145 mm. the percentages of hydrogen, butene, methane and ethane in the products are, respectively, 2·14, 4·1, 31·4 and 13·4; when the increase of pressure is 357 mm. these percentages are, respectively, 2·14, 3·9, 32·9 and 14·5 (the analyses are by mass spectrometer). The other constituents are also consistent with primary formation of lower paraffin and olefine.

Ethane itself could not, of course, give methane and olefine in one step; that it gives methane by some process is already known. Propane does the same; but this cannot have much bearing on the primary behaviour of higher hydrocarbons, nor upon the question whether and to what extent the reactions involve chain processes. Steacie and Puddington[1] have shown that the primary decomposition of propane gives approximately equal amounts on one hand of propylene and hydrogen and on the other of methane and ethylene.

C. N. HINSHELWOOD
C. J. DANBY
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South Parks Road,
Oxford. Oct. 21.

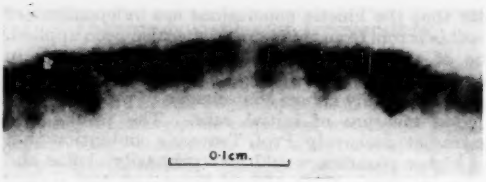
[1] *Canad. J. Res.*, B, **16**, 411 (1938).

Autoradiography of Metal Surfaces using a Radiochemical Method

A NUMBER of methods have been suggested for the autoradiographic study of metal surfaces. Variations of surface composition have been detected using differences in nuclear reactions occurring during irradiation[1], differences in radioactivity produced as a result of irradiation[2,3], and differences in contact potential leading to differences in adsorption of charged radioactive material[4]. The method described in this communication uses the different chemical reactivities of the various metal components towards some radioactive substance that forms a localized radioactive reaction product on the metal surface.

Experiments were carried out with amyl iodide containing some of the iodine-131 isotope, which has a half-life of eight days and emits both β- and γ-rays. The liquid as obtained had a specific activity of 1·5 mC./gm. It had an amber colour and probably contained free iodine, and it seems likely that this iodine, rather than the amyl iodide itself, was responsible for the chemical reactions observed.

When the liquid was placed on a clean copper surface, allowed to remain for fifteen seconds and wiped off with filter paper, a considerable amount of radioactivity remained on the copper surface. Autoradiographs of the copper surface were taken and measurements showed that the equivalent of 150 atomic layers of iodine was present on the copper surface, almost certainly in a chemically combined form. On a mild steel surface under the same conditions, the amount of activity was much less, equivalent to ten atomic layers only. Washing with cold



Autoradiograph of steel surface showing location of copper fragments transferred during sliding

water did not affect the activity on the copper; but it removed all but $2\frac{1}{2}$ iodine layers from the steel surface. It is possible that this residual iodine layer was of monolayer thickness only, the factor of $2\frac{1}{2}$ being the ratio of real to apparent surface area for the lapped steel specimen[5].

The accompanying illustration shows an autoradiograph of the friction track produced by a clean, hemispherically ended copper specimen sliding on steel under a load of 1 kgm., after which the iodine solution was applied for fifteen seconds, the surface washed with cold water and a two-day exposure given on 'No-Screen X-Ray' film. The copper wear fragments transferred to the steel are shown as black circular patches along the (curved) sliding track, while the background due to the steel is nearly invisible. The general appearance of the friction track is very similar to one shown by Rabinowicz and Tabor[6], who obtained their autoradiograph by an entirely different method using a radioactive copper specimen.

Of a number of metals and alloys examined, silver, chromium, lead and copper react most strongly with the iodine (~ 200 atomic layers); indium, tungsten carbide and brass react less vigorously (~ 50 layers); aluminium, bismuth, nickel, antimony, tin, cadmium and mild steel produce still thinner films (~ 15 layers); while zinc and titanium take up only three atomic layers.

The radiochemical method would appear to have considerable potentialities in surface autoradiography. Since only the surface itself is activated, good resolution can be achieved, while flexibility is ensured by the large number of radioactive chemicals and solvents that can be used to achieve a difference in the radioactive intensity at various regions on the surface.

E. Rabinowicz

Lubrication Laboratory,
Department of Mechanical Engineering,
Massachusetts Institute of Technology,
Cambridge, Mass. May 23.

[1] Hillert, M., *Nature*, **168**, 39 (1951).
[2] Rabinowicz, E., *Proc. Phys. Soc.*, A, **64**, 939 (1951).
[3] Michael, Leavitt, Bever and Spedden, *J. App. Phys.*, **22**, 1403 (1951).
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Gravitational Instability of a Turbulent Medium

Chandrasekhar has derived in a very elegant manner[1], from his theory of density fluctuations in an isotropic homogeneous turbulence field[2], the generalization to a turbulent medium of Jeans's criterion for the stability against inhomogeneity of an infinite quiescent homogeneous medium. The expression which he obtains may be written:

$$\lambda^2 = \frac{\pi}{G\rho}(c^2 + \tfrac{1}{3}\overline{u^2}) = \frac{\pi}{G\rho}\left(\gamma\frac{k\theta}{m} + \tfrac{1}{3}\overline{u^2}\right), \quad (1)$$

where λ is the critical length for stability, c is the speed of sound in the medium, θ the temperature, m the mass of a gas molecule, and $\overline{u^2}$ the mean square velocity of the turbulence field.

First, we should like to point out that because of the slow change in density in this process, the temperature will not vary adiabatically, as in the case of the relatively high frequencies involved in most acoustic radiation, but rather will approximately obey a polytrope law of the form

$$\theta = \theta_0\left(\frac{\rho}{\rho_0}\right)^{\alpha-1}, \quad (2)$$

where α is adjusted to give the best fit to the theoretical equilibrium temperatures[3]. One finds approximately $0{\cdot}4 < \alpha < 1{\cdot}00$ in H_{I} regions and $1{\cdot}00 < \alpha < 1{\cdot}04$ in H_{II} regions. Thus γ should be replaced by α in equation (1).

Secondly, we should like to point out that expression (1) may be derived by some simple physical arguments. From the virial theorem one sees that it is the internal translational velocities of the molecules which oppose the gravitational forces. The kinetic temperature is defined as a direct measure of these motions. Thus, we define a 'turbulence temperature' Θ by

$$3k\Theta = m\overline{u^2}. \quad (3)$$

We also assume that

$$\Theta = \Theta_0\left(\frac{\rho}{\rho_0}\right)^{A-1}. \quad (4)$$

Now, without turbulence,

$$\lambda^2 = \frac{\pi k}{G\rho m}\alpha\theta,$$

so that $\alpha\theta$ is the quantity characteristic of the internal stability of the medium. To include the turbulence, therefore, we simply replace $\alpha\theta$ by $\alpha\theta + A\Theta$. We obtain

$$\overline{\lambda^2} = \frac{\pi k}{G\rho m}(\alpha\theta + A\Theta). \quad (5)$$

If we assume, after Chandrasekhar, that $\overline{u^2}$ is independent of time, while ρ is varying, then $A = 1$ and we have:

$$y^2 = \frac{\pi k}{G\rho m}(\alpha\theta + \Theta).$$

If

$$c^2 \equiv \alpha\frac{k\theta}{m},$$

and is the velocity of sound with period less than the thermal relaxation time of the gas, then we may write

$$\lambda^2 = \frac{\pi}{G\rho}(c^2 + \tfrac{1}{3}\overline{u^2}).$$

E. N. Parker

Department of Mathematics and Astronomy,
University of Utah.
Salt Lake City.
Utah.
May 27.

[1] Chandrasekhar, S., *Proc. Roy. Soc.* A, **210**, 18 (1951).
[2] Chandrasekhar, S., *Proc. Roy. Soc.*, A, **210**, 26 (1951).
[3] Spitzer, jun., L., and Savedoff, M., *Astrophys. J.*, **111**, 593 (1950).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 15

SCHOOL OF PHARMACY, UNIVERSITY OF LONDON (in the Chemistry Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. C. D. Darlington, F.R.S.: "Genetics and Medicine".*

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. H. E. Harbour: "The Chemical Control of Animal Parasites".*

Tuesday, December 16

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.15 p.m.—Dr. J. H. Hamence, Dr. N. H. Pizer and Dr. G. W. Cooke: Papers on "The Determination of Phosphorus and Potassium in Acid Extracts of Soils".*

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. Roger Russell: "Experimental Studies of Hereditary Influences on Animal Behaviour".*

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. D. F. Rushman: "Radio-chemistry in Paint Research".

Tuesday, December 16—Wednesday, December 17

ASSOCIATION OF UNIVERSITY TEACHERS (at Trinity College, Cambridge).—Meeting of the Central Council.

Wednesday, December 17

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Rt. Hon. Lord Merthyr: "A Reformed Calendar".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. Jean Hanson: "The Sub-Microscopic Structure of Muscles".

INSTITUTE OF FUEL (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Papers on "The Sulphur Content of the Flue Gases discharged from Power-Station Chimneys".

Thursday, December 18

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. N. S. Hawley: "Functions of Several Complex Variables".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 6.15 p.m.—Dr. Arthur Hughes: "Aspects of Cell Life—Behaviour of Embryonic Cells in Tissue Culture".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Prof. S. Sambursky: "Science in Israel".

Thursday, December 18—Friday, December 19

PHYSICAL SOCIETY (in the Physical Laboratories, The University, Manchester).—Autumn Provincial Meeting on "Ionization Loss by Relativistic Particles".*

Friday, December 19

BIOCHEMICAL SOCIETY (in the Department of Biochemistry and Chemistry, St. Bartholomew's Hospital Medical College, Charterhouse Square, London, E.C.1), at 2 p.m.—Scientific Papers.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Brigadier R. A. Bagnold, F.R.S.: "Navigation on Land".

Saturday, December 20

NUTRITION SOCIETY (in the Department of Biochemistry, The University, Sheffield), at 10.15 a.m.—Conference on "The Role of Vitamins in Metabolic Processes".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BOTANIST (male) (Pass degree in botany is essential) in the Field Investigation Department, to work on the determination of damage to grain and other seeds by mechanical harvesting—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (December 19).

ASSISTANT CHEMIST at the Sewage Treatment Works, East Hyde—The Town Clerk, Town Hall, Luton (December 20).

ASSISTANT LECTURER IN ANATOMY—The Secretary, University College, Gower Street, London, W.C.1 (December 20).

PRINCIPAL SCIENTIFIC OFFICER at the Propulsion Research Laboratory, Salisbury, South Australia, to be responsible for initiation and general supervision of research and development in the fields of general physics and instrumentation related to rocket propulsion research—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (December 20).

LECTURER and a SENIOR LECTURER IN ANATOMY—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (December 31).

PRINCIPAL AGRICULTURAL ECONOMIST AND HEAD OF THE AGRICULTURAL ECONOMICS DEPARTMENT with the status of Reader—The Registrar, The University, Manchester 13 (January 13).

SCIENCE STUDENTSHIPS at the Military College of Science, Shrivenham—The Secretary, Ministry of Supply (Est.3.c), Room 519, Carlton Hotel, Haymarket, London, S.W.1 (January 14).

AGRONOMIST (Ph.D. in agronomy, with specialization in soil fertility, is the minimum requirement)—The Secretary, Tobacco Research Board, P.O. Box 1909, Salisbury, Southern Rhodesia (January 15).

CHAIR OF PHYSICAL CHEMISTRY at the Institute of Cancer Research (Royal Cancer Hospital)—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 15).

SENIOR LECTURER, a LECTURER, and a FELLOWSHIP (temporary), IN THE DEPARTMENT OF CHEMISTRY AND CHEMICAL TECHNOLOGY, University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (January 15).

READERSHIP IN STATISTICS at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 20).

CHAIR OF ELECTRICAL ENGINEERING in Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (January 31).

GRADUATE ASSISTANT (physiologist with knowledge of modern physical techniques, who would be interested in cardiovascular system)—Dr. G. S. Dawes, Nuffield Institute for Medical Research, Oxford (January 31).

LECTURER IN CIVIL ENGINEERING at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (January 31).

ASSISTANT DIRECTOR OF THE COMMONWEALTH INSTITUTE OF ENTOMOLOGY—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (February 28).

ASSISTANT LECTURER (with an honours degree and interested in the physical aspects of biochemistry) TO TEACH CHEMISTRY AND PHYSICS, and to co-operate in the research work of the Scottish School of Bakery—The Secretary, Royal Technical College, Glasgow.

ASSISTANT LECTURER (Grade A) TO TEACH PHYSICAL CHEMISTRY to B.Sc. and A.R.I.C. standard—The Principal, School of Technology, Tower Ramparts, Ipswich.

BIOCHEMISTRY GRADUATE (Ph.D.) with experience in the enzyme field, to collaborate on research on the enzymes of developing red blood cells—The Regional Director, Blood Transfusion Service, Royal Infirmary, Edinburgh 1.

BOTANIST to assist in the preparation of Flora of Tropical East Africa at Royal Botanic Gardens, Kew—The Under-Secretary of State, Research Department (S.610), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

DEMONSTRATOR IN BOTANY—The Registrar, The University, Nottingham.

MECHANICAL AND ELECTRICAL ENGINEERS for design, operation and maintenance of ground mechanical and electrical works services on R.A.F. and Civil Aviation stations, home and overseas—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.29./52A.

MECHANICAL or ELECTRICAL ENGINEER (with a first- or second-class honours degree in mechanical or electrical engineering) at a Ministry of Supply Design Establishment at Chertsey, to investigate vehicle ride performance, including experimental determination of component stresses as found in fast cross-country vehicles, and vibration and noise characteristics as obtained during road and rig tests—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.690/52A.

METEOROLOGISTS in the East African Meteorological Department—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.57/88/01.

PHYSICAL CHEMIST or ENGINEER (with a first- or second-class honours degree, or equivalent, in chemistry or engineering) at the Royal Aircraft Establishment, Farnborough, to take charge of small section engaged on research and development work on manufacture and properties of reinforced plastics, with special reference to nature, production and properties of reinforced fibres such as glass and asbestos—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.755/52A.

PLANT PATHOLOGIST (with a degree in natural science with training in plant pathology) to investigate diseases of coffee at the Coffee Research Station, Ruiru, Kenya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27059/197.

REGIONAL TRIALS OFFICER (with a degree in agricultural or natural sciences, with practical experience in crop production) in charge of the Institute's trials in mid-Wales, a SENIOR TECHNICAL OFFICER (with a degree in agriculture or natural sciences, with suitable practical experience or postgraduate training in research) in the Seed Production Branch, to work mainly on root and vegetable crops, and a TECHNICAL OFFICER (with a degree in natural sciences or agri-

culture and, preferably with some practical or postgraduate experience) in the Crop Improvement Branch, mainly in connexion with the testing of plant-breeders' material at the Scale-Hayne Trial Station—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Senior Scientific Officer (with first- or second-class honours degree, and experience in organic chemistry or biochemistry) at the D.S.I.R. Food Investigation's Torry Research Station, Aberdeen, for work on the chemistry and biochemistry of extractives and volatile components in fish muscle that are responsible for flavour and odour in fresh, spoiling and cured fish—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.769/52A.

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